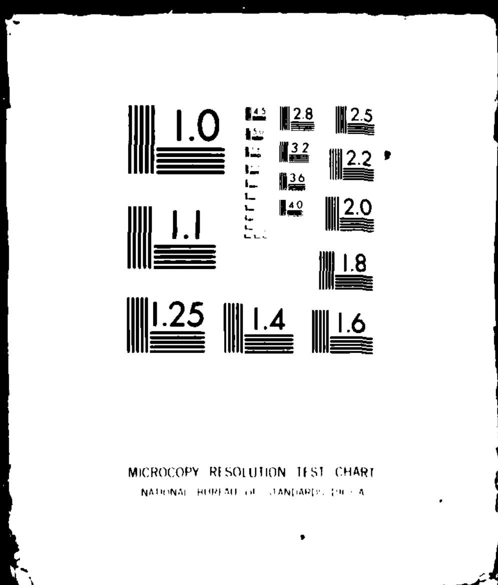
AD-A098 451 OHIO UNIV ATHENS DEPT OF ELECTRICAL ENGINEERING F/G 17/7
VLF P-STATIC NOISE REDUCTION IN AIRCRAFT. VOLUME I. CURRENT KNO--ETC(U)
SEP 80 R W LILLEY, R W BURHANS DOT-FA79WA-4320
UNCLASSIFIED EER-48-1 FAA-RD-80-137-1 NL

1 of 2

1 OF 2

AD-A 098451



Report No. FAA-RD-80-137, 1

VLF P-STATIC NOISE REDUCTION IN AIRCRAFT
Volume I: Current Knowledge

by
Robert W. Lilley
Ralph W. Burhans

Avionics Engineering Center
Department of Electrical Engineering
Ohio University
Athens, Ohio 45701

SEPTEMBER 1980

FINAL REPORT

Document is available to the U.S. public through
the National Technical Information Service,
Springfield, Virginia 22161.

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research & Development Service
Washington, D.C. 20590

NOTICE

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.: 19 18 FAA-RD-80-137-I

2. Government Accession No.: AD-A098451

3. Recipient's Catalog No.:

4. Title and Subtitle: 6 VLF P-STATIC NOISE REDUCTION IN AIRCRAFT. Volume I. Current Knowledge.

5. Report Date: 11 Sep[redacted]80

6. Performing Organization Code:

7. Author(s): 10 Robert W. Lilley, Ralph W. Burhans

8. Performing Organization Report No.: 14 EER-48-1

9. Performing Organization Name and Address:
Avionics Engineering Center
Department of Electrical Engineering, Ohio University
Athens, Ohio 45701

10. Work Unit No.:

11. Contract or Grant No.: 15 DOT-FA79WA-4320

12. Sponsoring Agency Name and Address:
Federal Aviation Administration
Systems Research and Development Service
Washington, D. C.

13. Type of Report and Period Covered: 9 Final Report. May [redacted]79 – Aug[redacted]80

14. Sponsoring Agency Code:

15. Supplementary Notes: 12 102

16. Abstract

In Volume I, the results of a literature search and facilities/capabilities survey to determine existing and LF p-static knowledge and noise-reduction techniques are presented. References treating basic p-static and corona theory, airframe quieting techniques and instrumentation methods are abstracted. A description of the Ohio University research aircraft installation for discharge current and static field environment is given.

Brief reference is made to lightning interference. Lightning discharges, although not p-static, are considered sources of Loran-C interference which should be characterized more specifically.

Volume II will present recommendations for further study and experimentation to permit better understanding of Loran-C interference processes, and procedures and techniques for minimizing their effects.

17. Key Words: VLF, Loran-C, p-static, dischargers, corona, navigation receives, interference

18. Distribution Statement: This document is available to the U. S. public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	100	

Form DOT F 1700.7 (8-69)

267460

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

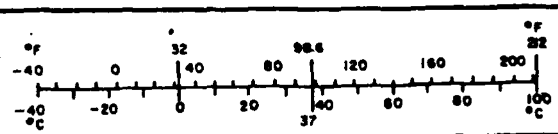


TABLE OF CONTENTS

LIST OF FIGURES

I. INTRODUCTION

Until recently, the trend in aviation navigation and communications has been toward the higher frequencies, avoiding the interference which plagued the lower-frequency radio ranges and direction-finders. While the VHF and UHF frequencies serve air-to-ground communications, point-to-point enroute navigation and precision landing requirements well, their line-of-sight restriction leads to a multiplicity of ground facilities and to operational problems at low altitudes or in mountainous terrain.

The VLF and LF end of the spectrum, therefore, has attracted new interest as the aviation community looks forward to the flexibilities inherent in random-navigation modes of operation. Additionally, cognizant government agencies are properly attracted to a system which requires only a fraction of the ground installations required at VHF, with consequent reduction in maintenance and monitoring costs.

Modern signal-processing techniques allow creative navigation receiver designs at the low frequencies which make the most of a given signal-to-noise ratio. However, the dependence for IFR navigation upon low-frequency radio transmissions forces us to relook the airframe p-static/corona noise problem and the interference caused by atmospheric discharges, as they affect the quality of navigation outputs.

This study has concentrated on the Omega and Loran-C (100 KHz) navigation systems, and on the potential interference generated by the airframe charging/discharging process during flight. While effects of atmospheric discharge (lightning) are not ignored during the literature search and subsequent study, they are mentioned here only briefly due to lack of prior work with Loran-C in mind, and due to the need to emphasize p-static and corona effects.

In order to characterize present knowledge in the aircraft p-static area, this study included an extensive literature search accompanied by a survey of available experimental facilities and organizations, plus initial activity to establish a local test bed for p-static measurements on the ground and in airborne experiments. Abstracts of applicable literature, descriptions of airborne instrumentation and results of preliminary flight missions are included in the Appendices to this report.

II. REVIEW OF LITERATURE

A. General. A literature search was conducted for information pertaining to precipitation static and related noise sources, with emphasis on aircraft application of Omega and Loran-C navigation. The field may be categorized as noise mechanisms, antennas, receiver circuitry effects, measurement techniques and noise reduction methods.

Mechanically, the search was carried out utilizing the Dialog computer-based information retrieval system [1], the Defense Technical Information Center, the National Technical Information Service, FAA Library and personal contacts by project team members. Reference was made to the collection of low-frequency navigation publications held by FAA personnel [2]. Hundreds of articles and reports were reviewed, abstracted and indexed. Nearly one hundred are applicable to the problem of p-static noise reduction in aircraft using low-frequency navigation systems, and these are presented in Appendix VI-A of this report. The citations are organized into five sections: Precipitation Static, Antennas, Dischargers and Anti-Static Coatings, Measurement Methods and Loran-C, with citations in alphabetical order by author.

B. Interference at Low Frequencies. External effects on the accuracy available in any practical low-frequency air navigation system originate in a variety of sources. At the very low frequencies used by the Omega (10.2 to 13.6 KHz) and the Loran-C (100 KHz) systems, a galaxy of propagation [3] and interference [4] errors must be considered. Fortunately, many propagation effects may be either minimized through computation of predictable time or position variation, and many external interference sources may be reduced through filtering or correlative signal processing.

Two additional important interference sources are essentially atmospheric in nature, in that they arise due to the normal operating environment of the aircraft. These sources, precipitation static/corona (p-static) discharge and atmospheric lightning, are of particular concern because they occur just at those locations where the aircraft is likely to encounter instrument meteorological conditions. Therefore, the noise and receiver de-sensitization caused by p-static and lightning events are likely to be present just when the pilot needs the navigation system the most.

C. Aircraft P-Static Interference. Precipitation static as an interference source at low frequencies has been evident in the literature since 1939 [5]. Numerous articles describing the basic phenomenon and experiments to measure its effects [6,7,8] have appeared. Reviews of the literature indicate no lack of understanding of the airframe charge-discharge mechanism and no lack of ideas, tried and untried, for controlling p-static noise. However, even a small literature sample demonstrates that most of the reported activity in p-static reduction has taken place on behalf of large, high-performance aircraft; the older B-47 [7], the Boeing 367-80 (the 707) [8], F-105 [9], F-4D [10,11] and the Navy P-3 Orion [12] all have come under relatively recent study. Each report offers recommendations for airframe quieting, antenna location and configuration and measurement techniques which are of interest and future use.

Recent years have seen rapid growth of the general-aviation fleet, increases in performance among the non-airline and non-military aircraft and increasing all-weather operation of private and corporate aircraft. This growth, combined with the renewed interest in the low-frequency spectrum for air navigation, requires consideration of LF and VLF noise as related to the general-aviation segment. Of course, the physics of p-static noise generation remains invariant. The differences for general aviation lie in the sheer number of aircraft, the design of their airframes and antenna installations, usage patterns, and the procedures by which aircraft systems are maintained over the life of the airframe.

The smaller single-engine or light-twin aircraft has been treated in the literature to some extent. Truax [13] reports on a Beechcraft Bonanza, Cessna 320 and a Lear 25 in p-static conditions. The Cessna 320 was instrumented for p-static measurements, and subsequently equipped with airframe dischargers and sealed antennas conductively bonded to the airframe. Significant p-static reduction was observed. Resistive coating was also applied to frontal non-metallic surfaces, to avoid streamer dischargers.

Butters [14] describes testing techniques for small aircraft, and outlines the p-static problem (airframe electrical gaps, need for wick dischargers, and streamer current problems on non-metallic surfaces). He calls for additional pilot education on discharger operation and maintenance.

D. Aircraft Antennas and Coupler Circuitry. The overall evolution of aircraft antenna design is a product of a wide variety of driving functions. Early designs required large structures with relatively wide spacing from the fuselage due to low frequencies and then-realizable receiver sensitivities, with minimal signal processing downstream. As navigation and communications frequencies were moved into the VHF/UHF region to minimize interference, antenna structures could become smaller while maintaining receiver signal-to-noise ratios. Higher aircraft speeds forced ever-smaller and more streamlined antennas, eventually resulting in flush or cavity-backed designs to minimize drag. Both electric and magnetic field antennas have always found their places in airborne applications, with the literature reflecting theoretical and experimental work [15,16,17,18].

Again, much of this antenna study and experimentation has been carried out using larger, high-speed aircraft, or for military craft, but the results are useful in the general-aviation case. Comparisons between E-field and H-field antennas are valid and important, since the smaller airframe places added restrictions on antenna placement. Antenna size and shape are still necessary considerations for p-static minimization, but increasingly for drag reduction. Even in fixed-gear light aircraft, current fuel costs force a new look at operating efficiency; the days of carefree addition of airframe appendages are (and should be) over.

At Omega and Loran-C frequencies, the antenna and preamplifier are often combined as an integral unit, with the antenna/coupler combination designed to drive a specific receiver input circuit. The behavior of this front-end circuitry in the presence of p-static interference must be designed for appropriate navigation system operation. Receiver AGC bandwidth, for example, can have a significant effect on p-static performance.

Theoretical justification for the performance of electrically small electric field antennas and magnetic field antennas is found in standard engineering texts [19,20]. The finer details of the effects of antenna shielding, proximity to adjacent structures, radiation from adjacent structures, and interference in general, are less well documented [21, 22]. However, a large body of knowledge exists as applied to low-frequency electromagnetic pulse reception (EMP) which must be considered in the proper design of navigation receiver antennas for frequency ranges such as Loran-C [23]. A possibly fruitful area for future theoretical design study of optimum performance airborne low-frequency navigation antennas would be a consideration of the methods employed in this EMP art [24].

The work of Kurt Ikrath [21,22] in particular leads to some experimental results on the effects of shielding and nearby coatings as applied to both E-field probes and H-field loop antennas. These results should be considered by antenna manufacturers in future designs. The work of Carl Baum and his colleagues in producing shielded antennas and novel Mobius loops for detecting broadband energy radiated from lightning strokes or as the result of nuclear explosions does not appear to have been applied to aircraft navigation antennas. Similarly, the work of Ikrath in devising novel ways of winding opposed-direction right-hand and left-hand sense rotation of loops to reduce or eliminate interference effects should be reviewed by antenna manufacturers.

The general statement can be made that any aircraft antenna which protrudes into the airstream is likely to be a source of discharge noise if the radius of curvature is very small, as in a thin wire or short wire whip antenna. Some work on this problem of the housing of antennas has been conducted previously [25] as applied to Omega and Loran-C receivers.

The literature on loop antennas suggests that there are several ideas that might be applied to design of Loran-C antennas which are not currently being used in aircraft systems [26,27,28,29,30,31]. The basic parameter design for loops has been well summarized by Meindl and his colleagues [28].

A problem of loop antennas as applied to Loran-C that often has not been considered in previous work is that of phase reversal of the signal from the transmitter when the direction of travel with respect to the source is reversed 180°. Thus, loop designs which might aid in reducing precipitation static will involve a more complex receiver processor. An idea which has been suggested but apparently not applied in practice is that of squaring the signal at low levels and adding the result from orthogonal loop pairs. This results in a signal at twice the original frequency, or at 200 KHz instead of 100 KHz for Loran-C. Some possible novel designs of low-cost receivers using loops might be obtained by further consideration of this idea [26].

An approximation for evaluating antenna sensitivity or capacitance and electrolytic tank measurement methods is summarized in Henney's handbook [32]. These would be of value to manufacturers in obtaining sensitivity data without actually constructing an airborne antenna, so that design ideas could be optimized prior to aircraft modification and more expensive field test work.

Another approach to Loran-C receiver design utilizes a hard-limiting sequential detector as opposed to a linear delay-and-add method for arriving at the third-cycle selection, and has apparently been applied with success in at least one airborne Loran-C receiver. This method of processing may inherently reduce high level impulse noise interference and possibly aid in reducing precipitation static noise [33].

E. Summary. Knowledgable persons in the industry [34,35] submit that the p-static problem is solved; that with our current theoretical background and measurement techniques we can predict airframe discharge locations and resulting RF coupling to airframe-mounted antennas. Further, we have the techniques for reducing the discharge potential of the airframe to acceptable levels for successful navigation and communications during all-weather operation of aircraft. Suitable test procedures are available and practical for handling the special cases. Indeed, such unexpected noise sources as decorative metallic decals applied over a painted surface have been found and corrected through such detective work. Airframe manufacturers understand the need for airframe electrical integrity and, most likely, a new aircraft is relatively quiet. Many light aircraft, however, are equipped with such accessories as bare-wire ELT antennas, an excellent source of corona noise; many are operating with no airframe dischargers installed. Many have composite or glass-fiber elements with no conductivity, an invitation to streamer discharge noise.

It must be demonstrated that typical general-aviation aircraft can be maintained in a low-noise state suitable for Loran-C or other low-frequency navigation systems on board. Significantly increased vigilance in the areas of discharger installation and maintenance, antenna design and location, and airframe electrical bonding may be required. Such maintenance would, it is felt, require at least an increase in pilot knowledge of p-static causes and effects, and information on available cures.

III. P-STATIC NOISE REDUCTION

"An increased awareness by pilots and by maintenance people of problems that can be caused by P-static is helping to isolate new avionics problems. A review of pilot reports often shows different symptoms with each problem that is encountered. The following list of problems is a summary of many pilot reports from many different aircraft. Each problem was caused by P-static:

- Complete loss of VHF comms
- Magnetic compass 30° in error
- Aircraft flies with one wing low while autopilot is on
- High pitched squeal on audio
- Motor boat sound on audio
- Loss of all avionics in clouds
- VLF navigation system inoperative most of the time
- Erratic instrument readouts
- "Center" suggested repairing poor radios
- "St. Elmo's Fire" on windshield

In general, each of these symptoms is caused by one general problem on the airframe. This problem is the inability of the accumulated charge from triboelectric charging (P-static) to flow easily to the wingtips and tail of the airframe, and be properly discharged to the airstream" [14].

Streamer discharges, resulting from migration of accumulated charge across nonconductive surfaces and eventual discharge to airframe components, produces noise components which are of concern up to about five MHz. Corona discharge, occurring principally from small-radius airframe and antenna elements exposed to the airstream, produce additional noise, troublesome out to approximately 50 MHz. Arcing, which occurs between imperfectly-bonded airframe components and accessories, can produce noise with significant components well above 100 MHz. The use of VHF and UHF frequencies for communications and navigation has avoided many of the effects of discharge noise; both corona and streamer noise are nearly 40 dB reduced at VHF frequencies compared with their VLF spectra.

Recent emphasis on noise reduction derives from increased interest in the low frequencies as carriers of navigation information; Loran-C, operating at 100 KHz, can certainly be expected to feel the effects of all three noise sources.

The aircraft-related noise described as "p-static" occurs when airframe discharge mechanisms are driven by charging phenomena associated with particle impact upon the aircraft. Such charging occurs to the greatest extent during aircraft encounters with ice crystals. The charge imparted to the aircraft by collisions with airborne particles builds to a threshold value related to airframe design, conductivity of the skin or outer film, and the presence of appropriate discharge points. These discharge points are preferably located at the same location as airframe discharger devices, but can also occur at antenna tips and other points of small curvature radius.

The issue of p-static noise reduction is, then, the issue of reduction of the airframe discharge threshold to a value such that discharges, when they occur, contain minimal energy and minimal coupling to aircraft communications and navigation antennas.

A. Airframe Dischargers. A wide variety of discharger designs is available on the commercial market. The inclusion of well-designed dischargers may be expected to improve airframe noise in p-static conditions by as much as 50 dB. Essentially, the discharger provides a path by which accumulated charge may leave the airframe quietly. This is generally accomplished by providing a group of tiny corona points to permit onset of corona-current flow at a low aircraft potential. Additionally, aerodynamic design of dischargers to permit corona to occur at the lowest possible atmospheric pressure also lowers the corona threshold. In addition to permitting a low-potential discharge, the discharger must minimize the radiation of RF energy which accompanies the corona discharge, in order to minimize effects of RF components at communications and navigation frequencies on avionics performance. These effects are reduced through resistive attachment of the corona point(s) to the airframe, preserving DC connection but attenuating the higher-frequency components of the discharge in concert with the capacitance along with the discharger. The required resistance varies inversely with frequency, with a range of one to 50 megohms in use.

Each manufacturer offers information concerning appropriate discharger location on specific airframes. Such locations emphasize the trailing outboard surfaces of wings and horizontal tail surfaces, plus the tip of the vertical stabilizer, where charge tends to accumulate on the airframe. Sufficient dischargers must be provided to allow for current-carrying capacity which will maintain airframe potential below the corona threshold of the trailing edges, and discharger spacing should be wide enough to prevent mutual shielding between adjacent dischargers. One such drawing for a light, single-engine aircraft appears as Figure 1.

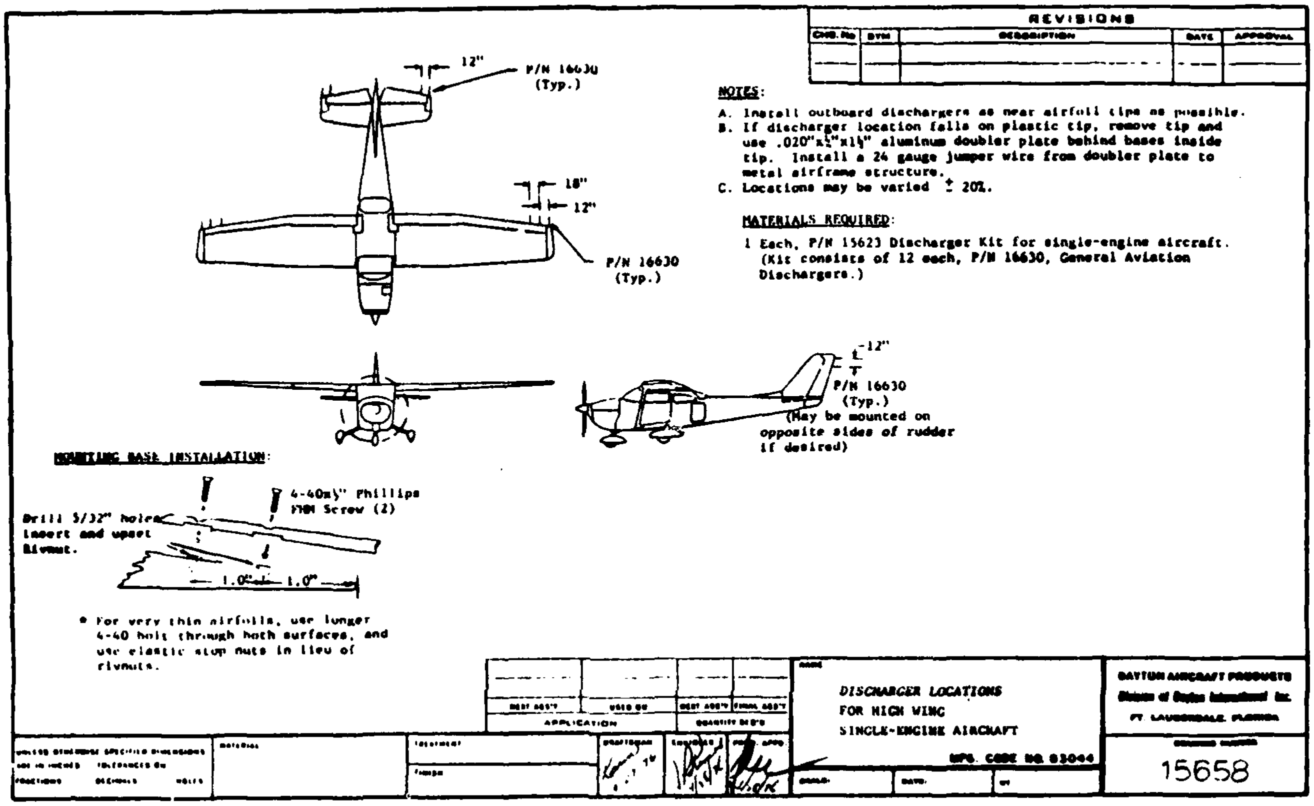
In general, the number of required dischargers increases as wingspan and aircraft speed increase.

At least one manufacturer recommends that dischargers be checked using a megohmmeter every 100 hours, with replacement if resistance does not meet manufacturers specifications. Also recommended is a frequent check of discharger base mounting, to avoid base-to-airframe resistance increases due to corrosion.

The literature and industry representatives unanimously agree that airframe dischargers form the fundamental step toward a quieter airframe in p-static conditions. The warning is voiced, however, that improperly designed or installed dischargers can cause more harm than good. The culprit is usually the decoupling mechanism; permitting radiation of excessive RF energy produced by the corona current during discharge.

B. Antenna Considerations. It is generally agreed that bare-metal, E-field antennas are particularly susceptible to corona discharges and impact noise when exposed to the airstream.

TYPICAL INSTALLATIONS OF STATIC DISCHARGERS



The proper number and placement of dischargers is of paramount importance. Detailed installation prints are available from Dayton Aircraft Products, for most aircraft.

P/N	Length	Diameter	Weight	Hole Spacing	Recommended Screws Qty.	Size	Type
16165	8"	.125"	.35 oz.	1" to 1½"	2	#10-32	Flat
16630	7"	.100"	.20 oz.	1"	2	#4-40	100°
24775-1	7.75"	.255"	.40 oz.	½" and 1"	3	#4-40	60°
14078	13.5"	.275"	.60 oz.	1" to 1½"	2	#8-32	Flat
14480	13.5"	.275"	.45 oz.	1" to 1½"	2	#8-32	Flat
12764	13.5"	.275"	.60 oz.	1" to 1½"	2	#8-32	Flat
16061	8.2"	.125"	.20 oz.	none	1	#6-32	Flat
15906	8.5"	.100"	.30 oz.	1-1/8"	2	#6-32	100°

Figure 1. Sample Installation Specifications for Airframe Dischargers. (Dayton Granger Corp., by permission.)

Most manufacturers now produce low-profile, coated antennas which, when well-bonded to the aircraft skin and when coatings remain intact, are relatively quiet. Cracks or punctures in the coating due to accidental damage, erosion or lightning events provide an ideal point for charge concentration and eventual corona from the antenna itself.

An antenna exhibiting corona will also reradiate the portion of the spectrum at which the antenna and its coupling circuitry are resonant, potentially affecting other aircraft antennas and systems.

Regular inspections and maintenance are required for all antenna systems to avoid the effects of imperfect bonding or lack of coating integrity. Antenna designs should stress streamlining, sealed construction, and avoidance of streamer discharge activity on the coating surface.

The literature search has disclosed some references leading to possible methods for simplifying design of H-field magnetic antennas. Loop antennas have the desirable property of reducing precipitation static in airborne systems at VLF and LF ranges. However, the loop has the undesirable feature of requiring knowledge of the direction of the signal because of a 180° phase reversal as the loop is rotated. The possibility of squaring the output of orthogonal pairs of loops separately and summing the resulting output has been suggested [26]. The idea appears not to have been evaluated in detail due to the lack of good squaring circuits at the time. The advent of high-frequency balanced modulators and dual-gate MOSFET transistors suggests the possibility of devising simple loop antenna preamplifier-coupler circuits which square the signal, then add with relatively simple circuits. If this is feasible, then it is also possible to eliminate the need for direction sensing and switching of antennas by external microcomputer processors as has been done with previous Loran-C loop antennas applied to aircraft operations. In effect, the antenna is continuously and automatically compensated for direction of arrival of the signal. Other references discuss the optimization of ferrite core loop systems which should greatly aid in the future experimental fabrication of Loran-C omnidirectional magnetic antenna systems [27,28,29,30,31]. See Appendix D for further detail of the squaring technique.

An attempt is underway to demonstrate improvement in P-static performance by using an array of E-field antennas at VLF. One configuration provides a top and bottom mounted pair of antennas, phased for addition of the VLF signal. The 180° orientation of antennas should permit cancellation of noise and addition of VLF signals. Tanner and Nanevicz investigated this property of decoupled antennas [8] in 1961 at higher frequencies in the MHz range. At these frequencies an improvement in noise performance of 25 dB was reported.

C. Nonmetallic Airframe Components. Weight, cost and aerodynamic efficiency advantages have encouraged the use of nonmetallic components in modern aircraft. Especially in designs for the smaller, general-aviation airframes, non-metallic surfaces represent an increasing percentage of aircraft surface area. Radomes, wingtips, and empennage components, plus windscreen and propeller spinner and, on some aircraft, the engine cowling offer the opportunity for streamer discharges. These streamer discharges are considered by Truax [34] to be the most significant noise problem for general aviation aircraft once the basic airframe arc points are quieted and dischargers are installed.

Accumulated charge must be conducted to the metallic airframe or discharged at a low potential to avoid interference from streamers. Conductive coatings have been used, with mixed results due to erosion in relatively few flight hours. Embedded conductors do not help significantly, since the streamer is essentially a surface phenomenon.

Streamer currents may be measured by placing conductive tape or paint around the non-metallic area to be measured, to collect the streamer currents before they reach the airframe. This measurement technique suggests methods for reducing stored potential on non-metallic surfaces by coating the inside surface conductively, protected from erosion. Then, very small holes may be made in the non-metallic material and filled with conductive material to permit the drawing off of the accumulated charge. The stored potential is then related to the inter-hole spacing. For windscreens, transparency may be retained by using a grid of fine wires, exposed at their intersections to the windscreen surface [36]. This technique is under investigation, but remains to be demonstrated, both in terms of noise reduction and light scattering/diffraction effects.

D. Airframe Quieting. Arcing among airframe components occurs when the dielectric strength of the medium separating the surfaces is exceeded. Arcing implies imperfect bonding among airframe parts, and the spark discharge which occurs during triboelectric charging contains significant components well into the VHF band.

Arcing noise emanates from imperfect conduction at hinge points, at the flashover potential at boundaries between conducting and non-conducting components, sometimes from access plates, and even from metallic ornamental nameplates or decals.

Test methods described by Truax [34] and Butters [14] can provide for relatively easy detection of arcing locations through use of a VHF pocket receiver. Such test methods could be adapted for ramp checking aircraft during regular inspections to maintain p-static performance.

Deicing devices, often in the form of rubber "boots" mounted on the leading edges of the airframe, can contribute to the airframe noise environment. Regular inspections will detect pinholes, aging or erosion damage which would allow arcing to the airframe from streamer potentials on the boots. Conductive material for deicing units would reduce the potential for noise.

The general issue of airframe quieting is that accumulated triboelectric charge be permitted to migrate with minimum restriction to the airframe extremities, where airframe dischargers can permit current flow into the airstream at a low discharge potential.

E. Receiver Circuitry. Modern signal-processing techniques can enhance receiver noise immunity through correlation techniques resulting in narrow effective bandwidths. Low-noise circuit components now in common use minimize internal receiver contributions to a system noise budget. The operating environment of flight in instrument meteorological conditions, however, calls for continuous operation of navigation equipment during severe noise contamination of the desired signal. The presence of static drain circuitry at the antenna, interference blanking circuitry, and appropriate receiver AGC bandwidth appear to be the important issues for p-static reduction.

The static drain is simply a resistive or inductive path to the airframe directly from the antenna. It allows removal of static charge accumulation on the antenna without permitting the antenna to reach its corona threshold. Given modern low-noise preamplifier/coupler circuitry, the preamplifier gain may be set such that the small reduction in antenna effective height resulting from the static drain will be negligible.

The interference blanker in its simplest form switches the receiver input off during a noise event. A number of blanker designs have appeared, some with fixed blanking characteristics triggered by a noise pulse which is sensed either by amplitude or rise-time detectors. Blankers offer some improvement in receiver operation, but suffer from several drawbacks. The blanker switching action in itself generates noise due to the modulation applied by the switch to interfering carriers near the desired signal frequency. Unless the blanking interval and the sensing detector are made rather "intelligent", the blanker can shut the receiver down entirely during periods of severe or prolonged noise activity, or due to such interference as power-supply noise. P-static conditions generate noise pulses which at times can cause continuous blanking due to high repetition rate.

Receiver desensitization due to p-static noise effects on AGC circuitry has been observed in the field. The optimization of AGC time constants, generally to narrow the typical AGC bandwidth, can improve receiver p-static characteristics. This improvement may be demonstrated through simple laboratory testing with a corona generator.

F. Other Topics. A variety of noise-reduction techniques have been suggested. A few are outlined here for documentation.

The reduction of corona threshold by ultraviolet light or alcohol vapor near sensitive aircraft has been mentioned by Ikrath [21]; a radioisotope-based discharger could provide improvement also. Generally, such reduction techniques tend to be impractical due to complexity, and unnecessary since modern airframe dischargers reduce the corona threshold to values (3-4 Kv) which are manageable provided appropriate RF decoupling is also present in discharger design.

Tracking biased dischargers, which utilize a high-voltage power supply on the aircraft, coupled most often to the airstream through a tailcap-mounted discharger, have been suggested as a means for maintaining a low aircraft potential. Most experimentation has centered on helicopters, in an attempt to protect ground personnel while handling cargo.

IV. P-STATIC EXPERIMENTATION

A. Experimental Facilities and Capabilities. Future advances in airframe discharge while avoiding significant interference with low-frequency navigation reception will depend upon both procedural and technical changes. The experimental investigation of airframe discharge as it affects low-frequency antenna structures and receiver circuitry requires instrumentation, both on the ground and in airborne installations. In both ground and airborne, such experimentation need not begin from zero. Facilities and experience exist, and those judged to be of near-term applicability are detailed in this section.

1. Wind Tunnel Testing.

a. Existing Facility. The Five-Foot Fire Test Facility wind tunnel at FAA Technical Center (FAATC), Atlantic City, New Jersey, offers a sixteen-foot long test section, with air velocities of up to 670 miles/hour. FAATC personnel [37] verified facility availability for low-frequency noise experimentation, and offered aid in instrumenting the facility for high-voltage measurements and for introduction of ice crystals into the airstream.

This facility is considered potentially valuable for testing biased airframe discharger operation, for comparative antenna and discharger evaluations, and for collecting baseline data on noise content for use in later receiver circuitry experiments.

b. Small-Scale Wind-Tunnel for P-Static Experimentation. Useful comparisons among various E-field and H-field antenna configurations were carried out by Ikrath [21, 22] using a small, "tabletop" wind tunnel, with water or ice particles simulated by small plastic-foam pellets. Ikrath's tunnel was a closed annular space, driven by ordinary squirrel-cage blowers, with air exhausted from the top of the unit.

Using this small wind tunnel, the expected insensitivity of ferrite-loop antennas to p-static interference when compared with metal-rod, E-field antennas was confirmed. Ikrath also carried out a series of experiments concerning loop antennas in close proximity to metallic surfaces. Such close proximity, when the separation is less than 10 cm, clearly increases the loop suceptibility to p-static effects.

This low-cost, convenient technique may find use in comparative antenna tests prior to airborne evaluation, and may allow full investigation of such parameters as antenna coating resistivity in a controlled p-static environment, with later verification in flight. Estimated costs for fabrication of this small wind-tunnel device are on the order of a few hundred dollars.

2. Instrumented Aircraft.

a. Ohio University DC-3. As a part of this work, Ohio University's Avionics Engineering Center installed instrumentation and airframe discharger mounts on its DC-3 aircraft, N7AP, with meter and chart recorder outputs. Figure 2 shows

Figure 2. Granger 16375 Dischargers Mounted on the DC-3 Right Wing. Not visible are the wires to the cabin for measuring discharge current. Dischargers are mounted on insulated standoffs, attached to wing and aileron ribs.

the Dayton-Granger P/N 16375 dischargers in place on the DC-3 right wing. The complete discharger set was installed in accordance with Granger specifications (see Figure 3). A set of TCO Company ESD-3 dischargers is also available, together with Granger 16165 units. Figure 4 shows the slight changes in discharger position recommended by TCO for their dischargers.

The Granger 16375 dischargers are advertized as LF/VLF units, while the 16165 units are the standard airline discharger. The TCO Company ESD-3 units are for use at LF/VLF frequencies.

The control and metering panels for the instrumented dischargers are shown in Figure 5, installed in the flight-check panel of N7AP. Using this experimental discharger configuration, the DC-3 can be used for in-flight comparisons among discharger design types. Installation schematics are given in Appendix VI-B.

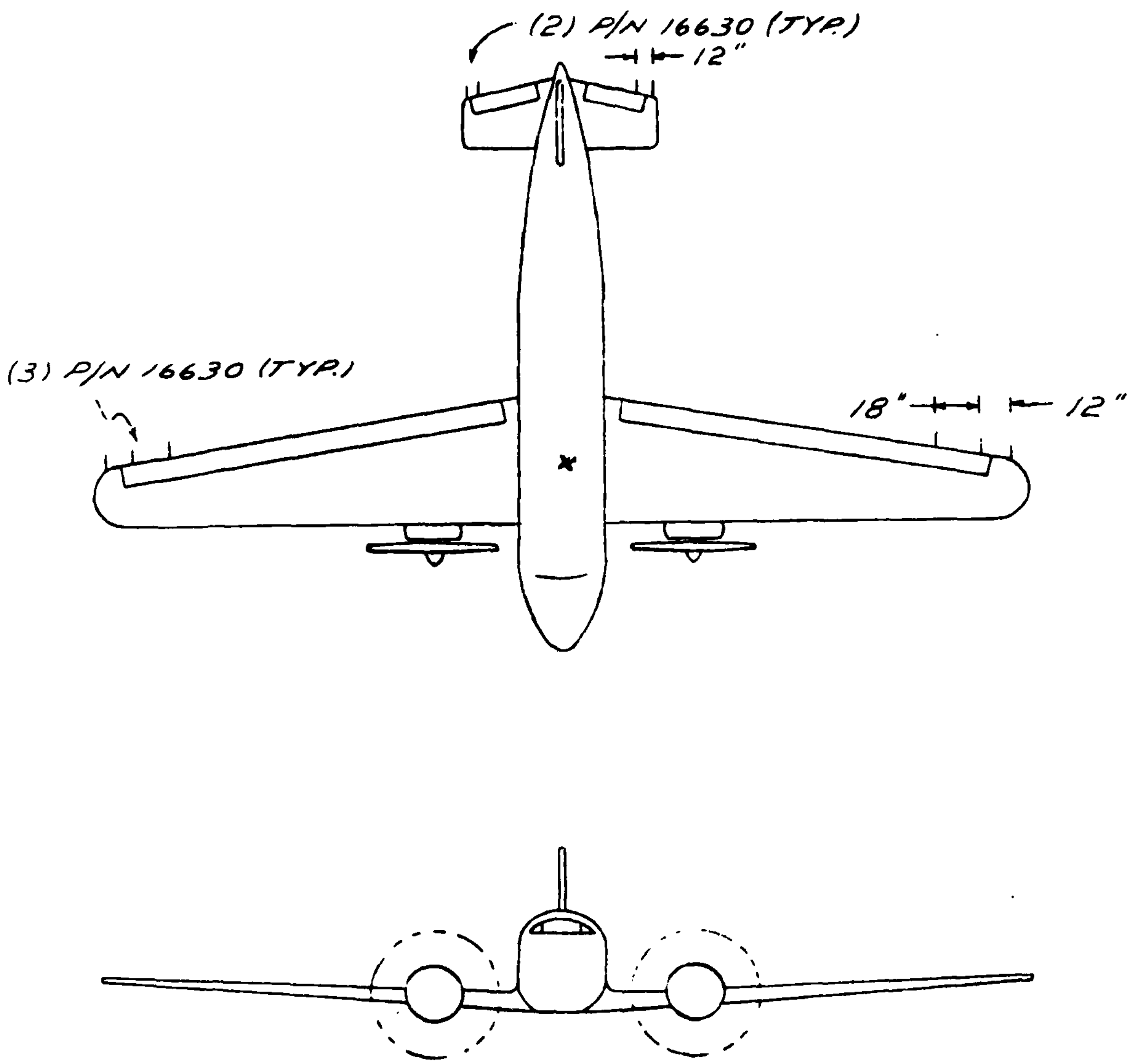
A biased discharger, of the type introduced by Nanevicz and Tanner [7] is to be installed in the near future. This unit consists of a high-voltage power supply installed in the aircraft, coupled to the surrounding space through a tail-cap discharger array. Loss of charge-carrying ions from the tail-cap discharger causes the airframe to assume a net charge with respect to its surroundings. When this stored charge exceeds the threshold potential at wingtips and other "hot" surfaces, discharges occur. The airframe can be charged in either polarity, permitting test flexibility, simply by reversing the high-voltage supply polarity.

The major advantage of the biased discharger is to permit p-static testing in clear-air conditions, avoiding flight evaluations requiring IFR conditions. Favorable p-static test conditions are often accompanied by turbulence and icing.

Figure 6 shows the top-mounted field probe, one of a pair mounted top and bottom to detect crossed-field conditions and the static electric field in the aircraft vicinity. A Monroe 225K electric field meter is mounted at the operating position in the cabin, with a switching unit allowing automatic commutation between top and bottom probes, or manual selection of either probe. Documentation for the switching unit is included in Appendix VI-B of this report.

Remaining instrumentation for p-static measurements is generally mission-oriented for a particular experiment. Ohio University-designed VLF and Loran-C receivers have been flown, as has the Teledyne TDL-711 receiver. Future plans call for Loran-C instrumentation using the Northstar 7000 Loran-C receiver, with appropriate digital data-collection units.

The DC-3 offers an example of an older, well-used airframe, which can be expected to evidence discharge noise from imperfect bonding among airframe components and to antenna bases. Plans are to perform a complete airframe survey to locate, document, and eliminate noise sources originating at the aircraft, to avoid interference with Loran-C p-static measurements.



REQUIRED PARTS

(13) P/N 16630 TRAILING DISCHARGERS

NEXT ASS'Y	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES	MATERIAL	TREATMENT FINISH	DRAFTSMAN Karen 1/24/7

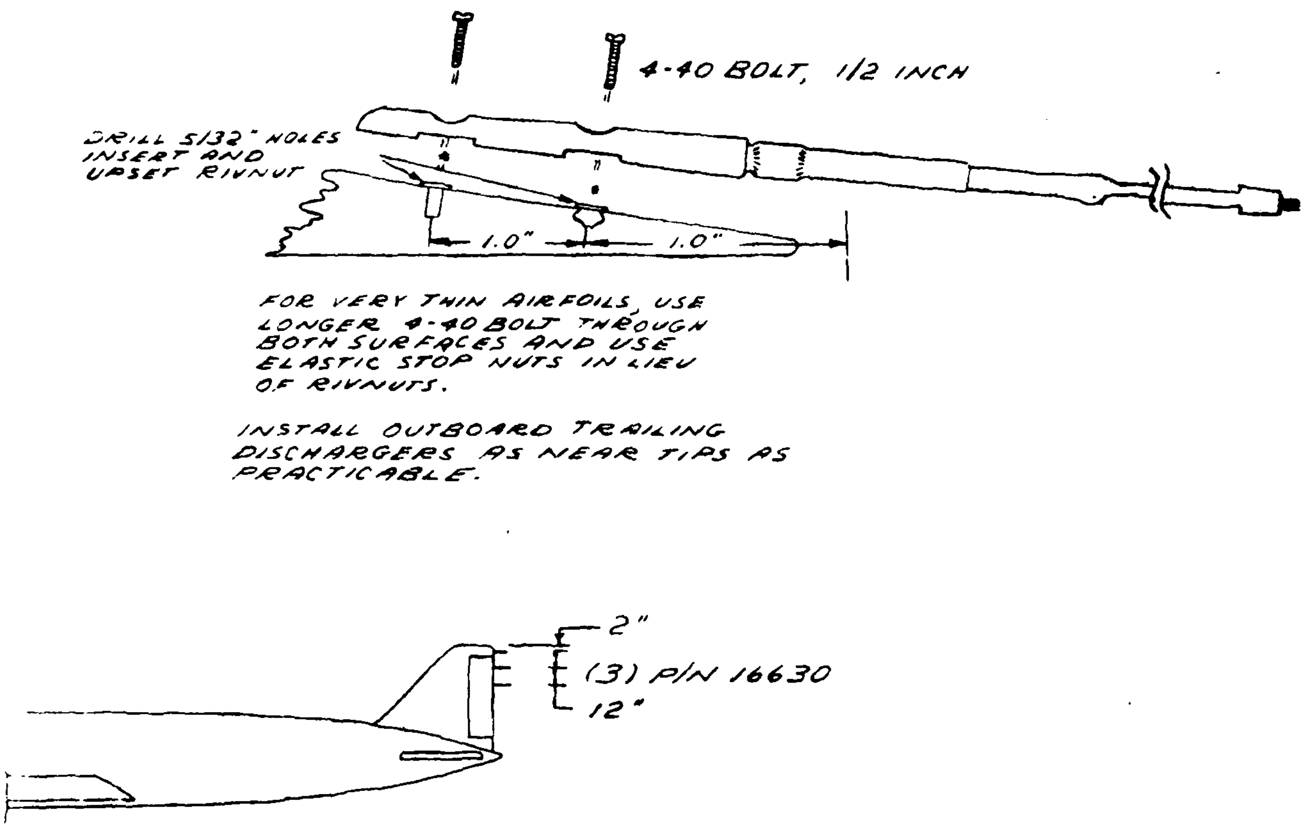
Figure 3a. Suggested Locations for Dayton-Aircraft Products, Inc. Dischargers on the DC-3 Aircraft.

REVISIONS

CHG. No.	SYM.	DESCRIPTION	DATE	APPROVAL
	A	REDRAWN WITH CHANGES	[illegible]	[illegible]
	B	NAME CHANGE	[illegible]	[illegible]

MOUNTING BASE INSTALLATION

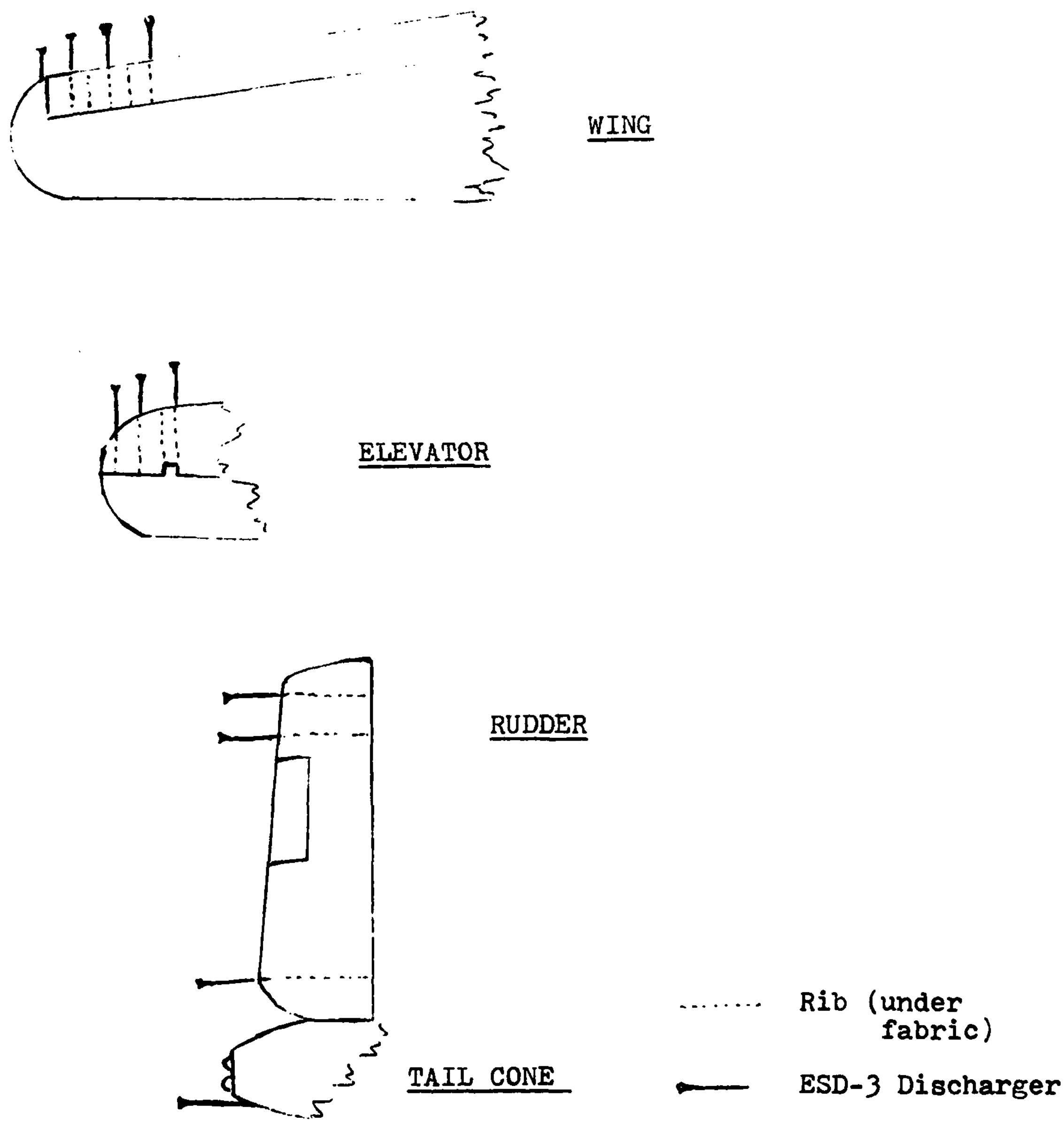
TRAILING EDGE DISCHARGER



JAN 8 1980

Figure 3b. Installation Diagram Micropoint Discharger Douglas - DC-3. (Dayton-Aircraft Products, Inc., Drawing Number 15447, by permission.)

THE TRUAX COMPANY



DC-3 Discharger Configuration

Prepared for: Ohio University

By: Robert L. Truax
5-21-80

Figure 4. TCO Company Suggested Locations for Dischargers ESD-3, by permission.)

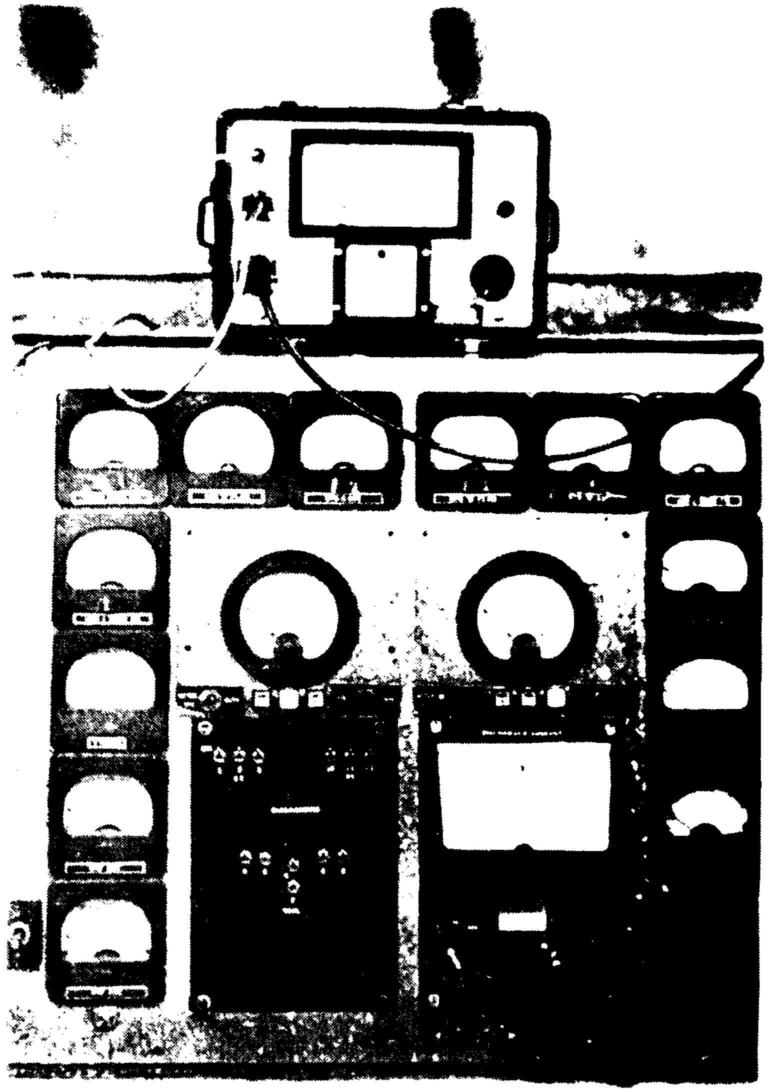


Figure 5. Metering and Control Panel for Instrumented Airframe Dischargers, DC-3 N7AP. The electrostatic field meter is mounted atop the DC-3 flight-inspection panel, and the discharger selector panel and metering/ chart recorder panel are at the lower center. Other instruments are original equipment from N7AP use as a flight-inspection aircraft, and are not used for p-static work.

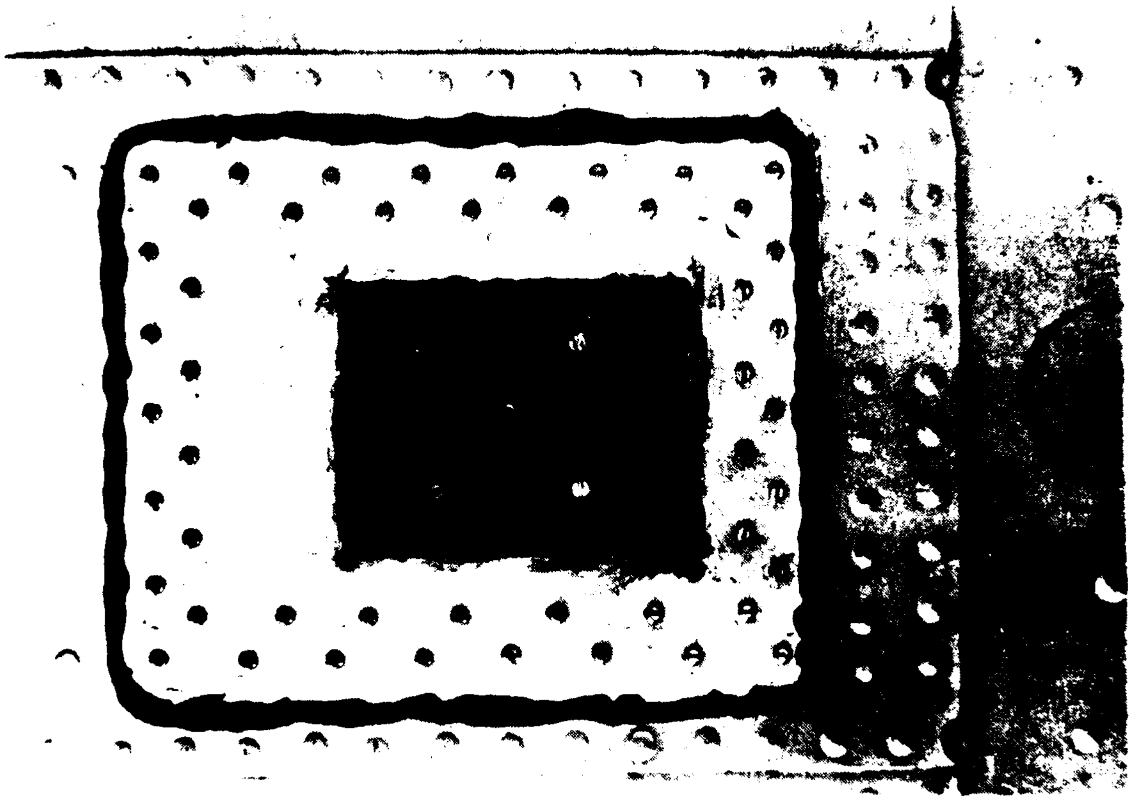


Figure 6. Top-Mounted Electrostatic Field Probe Mounted on DC-3 N7AP with Protective Cover Removed. A companion unit is mounted on the underside of the aircraft.

b. Dayton-Aircraft Products, Inc. The Dayton-Aircraft Products has available a C-310 twin aircraft with instrumented discharger mountings and metering panel installed. This aircraft, based at Dayton's Fort Lauderdale, Florida, location does not, at present, utilize static field probes in its data-collection.

c. Icing Conditions Generator. The Piper Aircraft Corporation has operated an Ice Machine [38] for airframe icing tests and certification evaluations. Basically a water-spray boom, suspended under a Cheyenne aircraft, when flown in sub-freezing temperatures, produces artificial icing on a following aircraft without dependence upon actual icing conditions. Since impact with ice crystals during flight is one mechanism by which p-static is generated, knowledge of this ice-generation facility may be of use in future experiments.

3. Static Test Facilities. A partial listing of available static test facilities is given, to permit planning of future experimentation.

a. The Truax Company, Fort Lauderdale, Florida [34]. The Company offers a complete airframe survey, including effects of imperfect airframe bonding, discharger presence and absence, RF survey at navigation and communications frequencies, and streamer current noise. A complete test sequence takes from two to three working days, and can be performed safely in a typical aircraft hangar, provided approximately ten feet of clearance exists between aircraft and hangar surfaces. This test sequence, while not performed in flight (where airspeed would enhance charge transport from the aircraft), simulates the removal of charge from the aircraft through the use of trailing-edge collectors.

b. Small-Aircraft Test Methods. Butters [14] describes simple corona-point tests which can be performed on small aircraft in less than a day. Butters stresses that each aircraft has an individual history and must be considered as a unique test problem.

B. Computational Facilities and Capabilities. Two computer programs have been implemented which may provide support for future work in the VLF noise area. The first is a signal and propagation model, which allows introduction of noise components, and the other is a thin-wire antenna/scatterer model, which may find use in analysis of specific airframe discharger designs.

1. Low-Frequency Radio Coverage Programs [39]. This collection of Fortran programs, available on the Ohio University computer facility, permits computation of expected signal-to-noise values for low-frequency signal propagation under a variety of conditions. The programs will operate in the range of 10 KHz to 100 MHz, considering effects of propagation path, antenna heights and ground-wave/skywave differences. The programs have been used successfully at Ohio University in past work in the 200-400 KHz frequency range.

2. Radiation and Scattering by Thin-Wire Structures [40]. This Fortran computer program has been used repeatedly in analyses of antenna and scattering structures by Ohio University. The program accepts radiator dimensions and conductivity, plus characteristics of immediately surrounding material (sleeving or plastic coating). Outputs include current distribution, impedance, radiation efficiency, antenna pattern, and near-zone field.

This computer routine should find use in determining the potential for coupling of discharge-generated fields from airframe dischargers to aircraft navigation and communications antennas.

V. REFERENCES

[1] DIALOG Information Retrieval Service, Lockheed Information Systems, Inc., Palo Alto, California (available by dial-up computer terminal).

[2] Project Technical Officer G. Quinn, of FAA Washington Headquarters, maintains an extensive collection of materials on low-frequency navigation and associated subjects. This collection was made available to the project team; a computerized index of this material was produced during the project.

[3] Veronda, C., "Bibliography and Comments on Loran-C Ground Wave Propagation", Report DOT-TSC-RSPD-77-2, Transportation Systems Center, Department of Transportation, Cambridge, Massachusetts, December, 1977.

[4] Mauro, P. G., Gakis, J. D., "The Effects of Primary Power Transmission Lines on the Performance of Loran-C Receivers in Experimental Terrestrial Applications", Report DOT-TSC-RSPA-79-8, Transportation Systems Center, Department of Transportation, Cambridge, Massachusetts, October, 1979.

[5] Hucke, H. M., "Precipitation Static Interference", Proceedings IRE, Vol. 27, May, 1939, pp. 301-306.

[6] Pearce, D. C., and B. W. Currie, "Some Qualitative Results on the Electrification of Snow", Canadian Journal of Research, Issued by the National Research Council of Canada, Vol. 27, Sec. A., No. 1, January, 1949.

[7] Tanner, Robert L., "Precipitation Particle Impact Noise in Aircraft Antennas", IRE Transactions on Antennas and Propagation, Vol. AP-5, No. 2, April, 1957, pp. 232-236.

[8] Tanner, R. L., and J. E. Nanevicz, "Precipitation Charging and Corona-Generated Interference in Aircraft", Stanford Research Institute, Menlo Park, California, Technical Report 73, AFCRL 336, April, 1961.

[9] Nanevicz, J. E., J. B. Chown, and W. C. Wadsworth, "F-105 Loran-C Precipitation Static Problem", Stanford Research Institute, Menlo Park, California, Final Report, March, 1969.

[10] Nanevicz, J. E., J. B. Chown, and J. H. Priedigkeit, "Loran Antenna Study for F4-D and OV-10 Aircraft", Stanford Research Institute, Menlo Park, California, Final Report, December, 1972.

[11] Nanevicz, J. E., "Flight Evaluation of Induced-Noise Mechanisms on High-Speed Aircraft", Stanford Research Institute, Menlo Park, California, AFAL-TR-73-317, October, 1973.

[12] "P-C Aircraft Preliminary Electrostatic White Noise Investigation", Final Engineering Report, Dayton Granger, Inc., Fort Lauderdale, Florida, January 27, 1971 (P. 3).

[13] Truax, R. L., "Electrostatic Charging and Noise Quieting", Dayton Aircraft Products, Inc., Ft. Lauderdale, Florida, 1971.

[14] Butters, W. G., "Precipitation Static in General Aviation Aircraft", Symposium on Lightning Technology, NASA Langley, April 22, 1980.

[15] Granger, J.V.N., and J. T. Bolljahn, "Aircraft Antennas", Proceedings of the I.R.E., Vol. 43, No. 5, May, 1955.

[16] Eisenberg, R. L., and M. F. Williams, "Interim Report of Precipitation Effects on Omega Aircraft Receivers", NRL Memorandum Report 1810, Naval Research Laboratory, Washington, D. C., August 10, 1967.

[17] Eisenberg, R. L., "Precipitation Effects on Omega Aircraft Receivers", NRL Report 7055, Naval Research Laboratory, Washington, D. C., May 18, 1970.

[18] "Low-Frequency Airborne Antenna System", Final Report, Air Technology Corporation, Cambridge, Massachusetts, August 30, 1964.

[19] Jordan, E. C., "Electromagnetic Waves and Radiating Systems", Prentice-Hall Inc., published 1961, p. 3120316.

[20] Schelkuniff, S. A., and H. T. Friis, "Antenna Theory and Practice", J. Wiley and Sons, New York, published 1962.

[21] Ikrath, K., "Interference with Aircraft Radio Navigation and Communications by Precipitation Static from Ice and Snow Clouds", ECOM 4244, Army Electronics Command, Ft. Monmouth, New Jersey, NTIS AD-784 623, August, 1974.

[22] Ikrath, K., "The Susceptibilities of Electrical and Magnetic Antennas to Precipitation Static Noise, ECOM 4319, Army Electronics Command, Ft. Monmouth, New Jersey, NTIS AD A012 166, May, 1975.

[23] Baum, C. E., et. al., "Sensors for Electromagnetic Pulse Measurements Both Inside and Away from Nuclear Source Regions", IEEE Trans. on Ant. and Prop., Vol. AP-26, No. 1, January, 1978, pp. 22-35.

[24] Baum, D. E., et. al., "Electromagnetic Sensors for General Lightning Applications", NASA Conference Publication 2128, Lightning Technology Conference, NASA Langley Research Center, Hampton, Virginia, April 22-24, 1980.

[25] "Tail Cap and Ferrite Crossed Loop Antenna Mounted on Aircraft", Pickard and Burns Publication No. 1085, Project No. RP-58, No. 0, August, 1968.

[26] Cheng, D. K., and R. A. Galbraith, "Stagger-Tuned Loop Antennas for Wide-Band Low-Frequency Reception", Proc. IRE, Vol. 41, August 1953, pp. 1024-1031.

[27] Lidholm, S., and G. Netzler, "VLF Loop Antennas for Pulse Reception", IEEE Trans. on Aero. and Elec. Syst., Vol. AES-10, March, 1974, pp. 211-215.

[28] Pettingill, R. C., H. T. Garland, and J. D. Meindl, "Receiving Antenna Design for Miniature Receivers", IEEE Trans. on Ant. and Prop., Vol. AP-25, July, 1977, pp. 528-530.

[29] Stewart, J. L., "On Ferrite Loop Antenna Measurements", IRE Conv. Record, Vol. 5, Part 1, 1957, pp. 42-48.

[30] Rumsey, V. H., and W. L. Weeks, "Electrically Small, Ferrite-Loaded Loop Antennas", IRE Conv. Record, Vol. 4, Part 1,

[31] Jean, A. G., H. E. Taggart, and J. R. Wait, "Calibration of Loop Antennas at VLF", J. Res. of the National Bureau of Standards, Vol. 65, No. 3, July-September, 1961.

[32] Henney, Editor "Radio Engineering Handbook", McGraw-Hill Book Company, New York, 5th Edition, Chapter 19, 1959, pages 8-10.

[33] Vander Wall, P. W., and Durk Van Willigen, "Hard Limiting and Sequential Detection Applied to Loran-C", IEEE Trans. Aero. and Electronic Systems, Vol. AES-14, No. 4, July, 1978, pp. 649-661.

[34] Personal Conversation with Robert L. Truax, President, The Truax Company, Fort Myers, Florida, March 13, 1980.

[35] Personal Conversation with Jay D. Cline, Vice President, Dayton-Aircraft Products, Inc., Fort Lauderdale, Florida, March 11, 1980.

[36] Tecknit Corporation, EMI Shielding Division, Santa Barbara, California, 1979 Catalog, page 61ff.

[37] Personal contact between Dr. R. W. Lilley, Ohio University, with J. E. Demaree, FAA Technical Center, June, 1979.

[38] "Piper'c Ice Machine", Business and Commercial Aviation, July, 1979, p. 94.

[39] Berry, L. A., "User's Guide to Low-Frequency Radio Coverage Programs", Office of Telecommunications, U. S. Department of Commerce, OT Technical Memorandum 78-247, January, 1978.

[40] Richmond, J. H., "Radiation and Scattering by Thin-Wire Structures in the Complex Frequency Domain", Electroscience Laboratory, The Ohio State University, Report 2902-10, July, 1973.

VI. APPENDICES

APPENDIX A. LITERATURE REFERENCES

The references presented here are the result of the literature search conducted manually and by computer-directed search of NTIS, DDC, DIA and other sources. Abstracts are included for most citations, together with acquisition information.

A. Precipitation Static.

LIGHTNING AND STATIC ELECTRICITY CONFERENCE, 3-5 DECEMBER 1968. PART II. CONFERENCE PAPERS

Air Force Avionics Lab Wright-Patterson AFB Ohio
May 69 582p
Report No.: AFAL-TR-68-290-Pt-2

Abstract: This report presents the text of the unclassified papers presented at the Lightning and Static Electricity Conference, 3-5 December 1968. These papers discuss problems of lightning and static electricity as they pertain to aerospace vehicles. Research to solve these problems conducted by numerous US and foreign agencies, both governmental and industrial, is discussed. The sessions covered include fluids and fuels, grounding and bonding techniques, survivability of nonconductive materials in a lightning environment, and control of static electricity effects on nonconductive materials. (Author)

AD-693 135

INVESTIGATION OF "ANTENNA DUMPING" AS A MEANS OF REDUCING PRECIPITATION STATIC INTERFERENCE IN AIRBORNE OMEGA

AUTHOR: Baltzer, O.J.
TRACOR, Inc., Austin, Texas
Final Rept, January 1972
17p
Rept No: FAA-RD-72-1
Contract No: FA67WA1-134

Abstract: Omnidirectional E-field antennas (e.g., whip, blade, and long-wire antennas) have various practical advantages over crossed-loop antennas in airborne Omega; however, experience has shown that E-field antennas are much more susceptible to precipitation static. The author has proposed that the interference effects of p-static upon E-field antennas might be reduced by periodically discharging ("dumping") any accumulated voltage present on the antenna. The duration of each discharge would be extremely short (typically 0.1 microsecond); on this basis it was hypothesized that the electric field due to propagated electromagnetic signals (Omega) and the electrostatic field associated with p-static would show different recovery characteristics; with the radiative field recovering essentially "instantaneously". However, negative results have been obtained on observed Omega signals with the "antenna dumping" concept, both in laboratory monitoring and in aircraft flights. It is concluded the loss in sensitivity occurs as the result of relatively poor coupling of an E-field antenna to space.

ERROR PERFORMANCE OF VLF AND LF RECEIVING SYSTEMS WITH NONLINEAR ATMOSPHERIC NOISE REDUCTION

Westinghouse Electric Corporation, Boulder Colorado, Georesearch Lab
Final Technical Report
AUTHOR: Beach, Charles D., George, David C.
Sept. 70 261p
Contract: F30602-69-C-0057
Project: AF-487L

Abstract: From the measured characteristics of the noise impulses generated by lightning discharges, including those with multiple return strokes, a statistical model is developed to describe the atmospheric noise in the radio channel between 10 KHz and 100 KHz. Using this noise model, error rates are calculated for data systems using binary coherent phase-shift keying and M-ary frequency-shift keying, both coherent and non-coherent. In the systems analyzed the demodulator is preceded by non-linear amplifiers that use peak limiting, hole punching or logarithmic limiting to reduce the noise power. For estimating error rates, the demodulator outputs are derived, and then series approximations are used for the probability distributions of these outputs. The coefficients in each approximating series are developed in terms of the parameters of the receiving system and the statistics of the atmospheric noise modes. (Author)

AD-875 991/2ST

DETAILED ANALYSES OF PRECIPITATION DATA: FCC/USAF POPSI PROJECT

Federal Communications Commission, Washington, D. C., Research Division
AUTHOR: Carey, Roger B., Kalagian, Gary S.
15 Dec 70 49p
Rept No: R-7003

Abstract: The electromagnetic field strength measurements obtained during the 1966 FCC/USAF POPSI Project have been classified according to propagation mode and the data from periods of precipitation have been analyzed in detail. Cumulative probability distributions were generated for the effective radar reflectivities derived from the bistatic electromagnetic measurements and compared with the probability distributions of the surface rainfall rates derived from the accumulations of the United States Weather Bureau recording rain gauges in the area. The distribution functions were then adjusted by means of a least squares regression line. The relationship thus obtained has been compared with other Z-R relationships based upon the analysis of drop size distributions and has been tested against independent rain gauge data in the POPSI Project area. The final approximation resulted in a standard deviation for estimating Z(p) from R(p) of less than 1.6 dB for the New Jersey rainfall data. The altitude dependence of the reflectivity from precipitation-connected phenomena in the New Jersey coastal area has been demonstrated and discussed to some extent. (Author)

AD-718 270

ATMOSPHERIC ELECTRICITY

Pergamon Press 1957
AUTHOR: Chalmers, J. Alan

DISCHARGE OF CORONA POINT CURRENT FROM AIRCRAFT

Cornell Aeronautical Lab Inc., Buffalo, N.Y.
AUTHOR: Chapman, Seville
1 Dec 54 56p
Rept No: rm824 p5
Contract: nonr90400

Abstract: In a system for maintaining zero electrostatic charge on aircraft, where electric field meters on the surfaces of the wings control a high-voltage corona discharge point behind the tail of the aircraft, the primary factors influencing the magnitude of blow-away discharge current i are point potential V, aircraft speed v, point geometry, and space charge from the already discharged current. V must be large enough to create an electric field vector toward the rear to drive the discharge current into the space charge behind the point, but since this same V creates a field vector forward toward the aircraft skin, the point must be disposed so that the wind past the point prevents return current to the aircraft. The problem is approached mathematically from several points of view, to evaluate constants F, G, and H in $i = \epsilon_o(FkV^2/\ell + GvV + H\ell v^2/k)$, where k is the mobility and ℓ a length. The current should vary with the first powers of the speed and point potential, and be independent of mobility, and hence of polarity and altitude. For an aircraft speed of 100 meter/sec and a point potential of 100 kilovolts, the current should lie in the range 200-250 microamperes although calculations based on different approximations vary from 175 - 395 microamperes. Experiments in the laboratory with wind simulated by an electric field yield 225 microamperes. Limited experimental and in-flight data imply current of about 200 microamperes.

AD-118 584/2ST

P-3 AIRCRAFT PRELIMINARY ELECTROSTATIC WHITE NOISE INVESTIGATION

Dayton-Granger Inc., Fort Lauderdale, Florida
CN N00421-71-C-6250

Abstract: This preliminary investigation of electrostatic charging and resultant white noise RFI was conducted on P-3A S/N 148889.

The investigation established that P-3 aircraft will charge electrically in flight to levels that will result in corona discharge and arcing noise which will disrupt radio reception through the VHF spectrum. Further, that pulse penetration occurs to the internal aircraft wiring at levels that may degrade the operation of electrical and electronic equipment not associated with radio receivers.

The tests established that adequate dischargers will reduce corona discharge noise to acceptable levels, even during extreme charging conditions. Further, the dischargers will control the locations from which corona discharge will occur and they will significantly reduce the electrical energystored on the airplane.

Flight tests showed the necessity to use only antennas on P-3 aircraft which are adequately insulated from the external electrical fields surrounding an airplane. And, the importance of verifying their insulation on the airplane.

Further effort is needed to locate arcing noise sources and improve bonding as necessary. Also, locate the pulse penetration windows on the P-3 aircraft and take appropriate preventative measures.

Reliable data communications cannot be expected during electrostatic charging until the recommended improvements are made.

INVESTIGATION OF CORONA DISCHARGE FROM VLF ANTENNA CABLES IN VARIABLE DENSITY WIND TUNNEL

AUTHOR: Earshen, John J., Mohlke, Byron H.
Cornell Aeronautical Lab Inc., Buffalo, New York
Descriptive Note: Final report on Phases 1 and 2, June 69 150 p
Rept No: CAL-UM-2725-B-1
Contract: N62269-69-C-0072

DEVELOPMENT AND FLIGHT-TESTING OF PRE-PRODUCTION OMEGA AIRCRAFT RECEIVERS AND ANTENNAS

U S Naval Res Lab, Washington, D.C.
Inst. Navig, Washington, D.C., OMEGA Symp., Proc. 1st, Washington, D.C., Nov 9-11, 1971 144-154p
AUTHOR: Eisenberg, R. L., Thornhill, A. F., Williams, M. F.

Abstract: The Mark III receiver-computer was completed in 1968 and flight tested by NRL, the U.S. Army and the U.S. Air Force until 1970. The receiver was designed and constructed by NRL: the navigation computer by Lear-Seigler, Inc., under an NRL contract. The aircraft system included a crossed-loop antenna and preamplifier manufactured by Pickard and Burns Electronics and a loop antenna coupler developed by NRL. The Mark III displays include aircraft position in lattide/longitude, range and bearing to enroute destinations, cross-track error, and autopilot commands. The Mark III equipment provided one to two mile RMS geodetic accuracy during flight tests in the U.S., the North Atlantic, the Pacific and the Caribbean. During flight tests in 1968, the crossed-loop antenna system provided continuous Omega signals during a three-hour North Atlantic storm, when all communications and other radio navigation signals were obliterated by precipitation static. 6 refs.

INTERIM REPORT OF PRECIPITATION EFFECTS ON OMEGA AIRCRAFT RECEIVERS;

Interim Report
Naval Research Lab, Washington, D.C.
AUTHOR: Eisenberg, R. L., Williams, M. F.
10 Aug 67 50p
Report No: NRL-MR-1810

Abstract: Omega is a very-low-frequency (VLF) radio navigation system which is characterized by very-long-range capability and relatively high accuracy. Fixes with an accuracy of one to two miles can be obtained by ships, aircraft and submerged submarines within a range of more than 5000 nautical miles. Propagation studies have shown that eight stations will provide radio navigation information over the entire earth.

The performance studies of the Naval Research Laboratory's (NRL's) Omega aircraft receivers indicate that the use of the Omega navigation system for aircraft is entirely practical.

Evaluation flights demonstrate that in good weather and in areas of reasonable signal strength Omega provides excellent navigation for aircraft. In flight the aircraft position is continuously and readily available from counters on the front panel. However, precipitation static effects have had a detrimental effect on receiver operation. NRL and Pickard and Burns have conducted independent experiments to determine the effect of precipitation on the reception of VLF in aircraft. The results of the two independent experiments have been remarkably similar. On the majority of the NRL flights a two-foot vertical blade antenna has been used (the AN/104AX). This antenna, because of its high base-to-ground impedance, is susceptible to signal output reduction when the base insulator is wetted. A two-foot polyethylene insulated rod antenna has improved characteristics under wetting conditions, but both the blade and the insulated rod are still susceptible to static pickup. A loop antenna appears to have improved characteristics with respect to both wetting and static pickup. The blade and the loop antennas have been evaluated by both NRL and Pickard and Burns in the laboratory and in flight. Oscilloscope pictures in this report demonstrate the results discussed above.

This investigation of the reception of Omega signals in precipitation static in aircraft is continuing.

AD-660 377

PRECIPITATION EFFECTS ON OMEGA AIRCRAFT RECEIVERS

Final Report

Naval Research Lab, Washington, D.C.
AUTHOR: Eisenberg, R. L.
18 May 70 29p
Report No: NRL-7055

Abstract: Omega is a very-low-frequency (VLF) radio navigation system characterized by very long range and an accuracy on the order of 1 to 2 mi with respect to earth co-ordinates. Early flight tests of Omega aircraft receivers using vertical electric-field antennas achieved excellent results in good weather but experienced almost constant signal loss in precipitation conditions. Signal losses appeared to be caused by precipitation static and shorting of the insulation at the bases of the antennas.

Modifications of vertical antennas, including shielding of the leading edge and improved base insulators, reduced but did not solve the problem. An experimental NRL-designed-and-constructed crossed-loop antenna system improved reception characteristics with respect to both wetting and static pickup. NRL has evaluated the performance of modified vertical antennas and crossed-loop antennas in the laboratory and on Omega test flights. These flight tests have revealed that the crossed-loop antenna offers adequate sensitivity and a significant reduction of precipitation effects and thus provides all-weather operation of Omega aircraft receivers.

AN ATMOSPHERIC NOISE MODEL WITH APPLICATION TC LOW FREQUENCY NAVIGATION SYSTEMS

Massachusetts Institute of Technology, Cambridge, Department of Electrical Engineering
Descriptive Note--Doctoral Thesis: Feldman, Donald Alexander
June 72 206P
Contract: DOT-CG-13446-A

Abstract: A prerequisite of the design of low frequency radio receivers is a model for low frequency atmospheric radio noise that encompasse the non-Gaussian nature of the actual noise process and is sufficiently tractable to enable performance analysis and optimization of receiver designs. This work describes a new model for atmospheric noise waveforms observed at the output of the antenna bandlimiting filter. This model, which is based on statistical analysis of sample records of these waveforms, is used to analyze the performance of typical radio navigation receivers and to determine near optimum receiver performance. The analysis is verified by simulating the receiver structure and testing the receiver with the actual noise sample records. (Author)

PRECIPITATION SCATTER INTERFERENCE COMPUTATION

Federal Communications Commission, Washington, D.C., Research Div. (403 596)
AUTHOR: Fine, Harry
1 Sept 73 93p
Report No: R-7303

Abstract: The report supplements existing CCIR documentation on precipitation scatter interference, giving more details on assumptions and development of formulas for such interference. Techniques are developed for determining the location of maximum scattering volumes and computing the maximum permissible interference into the system to be protected. Vector and matrix methods are developed for computing the geometric parameters required for the computation of precipitation scatter interference. (Author)

PB-230 989/6

PRECIPITATION STATIC NOISE AND SHIELDING IN AIRCRAFT ADF LOOP ANTENNAS

AUTHOR: Grabowiecki, A., Kunachowicz, K., Inst. Lotnictwa, Warszawa, Poland.
Internat. Union of Radio Sci., Internat. Special Committee on Radio Interference, IEEE, et.al.
Pr. Nauk. Inst. Telekomun and Akust. Politech. Wroclaw. Ser. Konf. (Poland), Vol. 27, No. 7, 232-7, 1976.
3rd Wroclaw Symposium on Electromagnetic Compatibility, 22-24 Sept. 1976, Wroclaw, Poland.

Abstract: A noise-producing mechanism associated with the in-flight charging of an aircraft and its effect on the performance of airborne MF automatic direction finders are considered. The precipitation static noise is produced in antennas mounted under plastic radomes. In the presented model of a flush ferrite loop antenna, the spark discharge between the radome and the surrounding metallic surface is prevented by coating of the antenna surface with a conducting film of epoxy-carbon black gel. Measurements show that this shielding does not affect adversely the signal pick-up characteristics of the loop winding. (7 Refs)

ARMY-NAVY PRECIPITATION STATIC PROJECT

U. S. Naval Research Laboratory, Washington, D.C.
Aircraft Radio Laboratory, Wright Field, Dayton, Ohio
Proceedings of the I.R.E. and Waves and Electrons
Vol 34, 1946
Gunn Editor, et. al.

TACTICAL LORAN

AUTHOR: Higginbotham, L.D.
Wright-Patterson AFB, Ohio, USA
NATO, AGARD
Hybrid Navigation Systems: papers presented at the Guidance and Control Panel 9th meeting, 11pp. 1970
22-26 Sept 1969, Delft, Netherlands
Publ: AGARD Neuilly-Sur-Seine, France
VI+267

Abstract: For any navigation system to possess the greatest potential for tactical applications, it must be pilot operable and precise. Loran in its various forms has been with us for the past several decades and has provided adequate enroute navigation wherever the ground environment has existed. With the advent of digital technology and the birth of digital airborne computers Loran has advanced to the state of automaticity and precision unmatched by any other existing navigation device. As such it is just beginning to fulfil its potential as a tactical navigation system. This paper reviews the USAF's efforts over the past five years to develop a military capability in Loran. Briefly it describes a tactical Loran system and its advantages and disadvantages as a common user grid system. It defines some of the problems encountered in the development of system hardware. Since Loran is a relatively low data rate system, emphasis is being given to the problems encountered when integrating the system into high performance aircraft. It describes the various methods of integration and the relative accuracies to be expected of each. It also includes the environmental aspects such as signal-to-noise ratios as affected by aircraft attitude, phase inversions and precipitation static noise. A status report is given on hardware technology and where this technology is leading in terms of weight, volume and cost. To overcome some of these limitations it is shown that simple retransmitting devices can satisfy many projected requirements for position locating by remotely processing the received signals. An attempt is made to define the areas of further development in the system for tactical purposes.

INTERFERENCE WITH AIRCRAFT RADIO NAVIGATION AND COMMUNICATIONS BY PRECIPITATION STATIC FROM ICE AND SNOW CLOUDS (ELECTROSTATIC WIND TUNNEL EXPERIMENTS)

Final Report Mar-July 74 on Phase 1
AUTHOR: Ikrath, Kurt
Army Electronics Command, Fort Monmouth, New Jersey, Communications/Adp Lab
Aug 74 45p
Report No: ECOM-4244
AD-784 623/1

Abstract: The effects of precipitation static noise interference with the reception of radio navigation and communication signals an aircraft flying through ice and snow clouds were generated with an electrostatic wind tunnel. Electrical type antennas were found to be highly susceptible to precipitation static noise fields, whereas magnetic antennas were found to be practically immune to these noise fields unless the magnetic antennas were in close proximity to metal surfaces.

THE SUSCEPTIBILITIES OF ELECTRICAL AND MAGNETIC ANTENNAS TO PRECIPITATION STATIC NOISE (EXPERIMENTS IN AN ELECTROSTATIC WIND TUNNEL)

AUTHOR: Ikrath, K.
Issued by: Army Electronics Command, Fort Monmouth, New Jersey, USA, May 1975
Report No: ECOM-4319

Abstract: The effects of precipitation static noise interference with the reception of radio-navigation and communications signals on aircraft flying through ice and snow clouds were generated. Metal-rod and blade antennas were found to be highly susceptible. Ferrite loopstick antennas were found to be practically immune if electrically conductive materials, such as wet or moist plastics or metal, were kept approximately 30 cm away. This critical distance was reduced to 10 cm from crossed ferrite loopsticks.

AD-A012 166/5ST

EFFECTS OF WEATHER ON AIRBORNE OMEGA

AUTHOR: Lubin, S. J., Lewis, B. M.
National Hurricane Research Lab, Miami, Florida
1972 7p
Published in Journal of the Institute of Navigation, V. 19, No. 2, p175-180, Summer 1972
COM-73-10196

FLIGHT EVALUATION OF INDUCED-NOISE MECHANISMS ON HIGH SPEED AIRCRAFT

AUTHOR: Nanevicz, J.E.
Stanford Research Institute, Menlo Park, California
TR AFAL-TR-73-317

Abstract: An aircraft interacting with its in-flight environment can generate radio interference of sufficient magnitude to disable communication and navigation systems. An instrumentation system was developed to study the physical processes associated with vehicle-induced electromagnetic interference experienced by supersonic aerospace vehicles. Flight tests using this instrumentation were conducted on an F-4D Phantom III aircraft at Elgin Air Force Base at subsonic speeds and at supersonic speeds as high as Mach 1.9.

Physical charging processes studied include frictional "triboelectric" charging of the aircraft skin by precipitation, charging of plastic surfaces, and engine charging. Many of the flight-test measurements were shown to verify predictions based on laboratory measurements and to agree with data measured on other aircraft at subsonic speeds. In particular, the precipitation charging during F-4D supersonic flight at Mach 1.2, 1.6, and 1.9 was compared to earlier laboratory tests involving the supersonic firing of projectiles through an ice-crystal cloud.

Measurements of corona discharges were also made. The radio interference induced by these discharges was measured using LORAN and Chelton test antennas, with and without commercial dischargers on the aircraft.

F-4D aircraft charging during refueling hookup with KC-135 tanker aircraft was also investigated. Data were shown in which sufficient energy was transferred to the F-4D to ignite fuel/air mixtures, to initiate electro-explosive devices, and to produce mild shock.

AIRBORNE MEASUREMENT OF ELECTROMAGNETIC ENVIRONMENT NEAR THUNDERSTORM CELLS (TRIP-76)

AUTHOR: Nanevicz, J. E., Adamo, R. C., Bly, R. T., Jr.
Stanford Research Institute, Menlo Park, California
Aug 77 78p
Contract: NAS9-15101
Project: 4363
Monitor: AFFDL-TR-77-62

Abstract: The increasing use of digital equipment and nonmetallic structures on aerospace vehicles has focused new attention on the potential electromagnetic threat posed by the lightning and thunderstorm environment. To better define this threat, a quick reaction airborne lightning measurement effort was undertaken. Digital 'snapshot' data and continuous analog spectrum analyzer data were alternately recorded on an instrumented NASA Lear jet during 29 flights. Recorded events included one direct lightning strike and many nearby strikes, as well as incipient lightning streamers and non-lightning-associated signals. A comparison with nuclear EMP waveforms is given, indicating nearby lightning to be a far more energetic threat than EMP at low frequencies, and that it is non-negligible at 10 MHz and above.

AD-A060 875/2ST

F-105 LORAN-D PRECIPITATION STATIC PROBLEM

AUTHOR: Nanevicz, J. E., Chown, J. B., Wadsworth, W. C.
Stanford Research Institute, Menlo Park, California

Abstract: Ground tests were conducted on the F-105 aircraft to determine the susceptibility of its LORAN-D canopy antenna to precipitation static interference. These measurements indicate that the AN/ARN-92 receiver can be made to lose track when the precipitation charging current to the front portion of the canopy reaches 2 $\mu A/ft^2$. On the basis of earlier flight test experience, it is argued that charging currents of this magnitude may be expected on the F-105 in flight. Recommendations for flight test verification of the ground test results and predictions are presented.

STATIC-ELECTRICITY ANALYSIS PROGRAM, VOLUME I

AUTHOR: Nanevicz, Joseph E., Douglas, Dennis G.
Stanford Research Institute, Menlo Park, California, Space and Missile Systems Organization, Los Angeles, California
Final Report Sep 73-Aug 74
Oct 74 91p
Report No: SRI-2919-FR-1
Contract: F04701-73-C-0401
Project: SRI-2919
Monitor: SAMSO-TR-75-44-Vol-1

Abstract: A computer program based on the results of earlier experimental and analytical studies of precipitation static interference was developed to permit the EMP engineer to calculate p-static noise levels on a variety of aircraft under various charging conditions.

The experimental and analytical data on which the program is based arc presented briefly. The approach and philosophy followed in preparing the computer model are discussed. Comparisons of predicted noise spectra to flight test data from a Boeing 707, an F-4, and a B-47 are given that verify the validity of the computer model. A discussion is presented of the applications and limitations of this first-generation computer model.

AD-A017 873/1ST

CORRELATION BETWEEN CLEAR-AIR TURBULENCE AND ELECTRIC FIELDS

AUTHOR: Nanevicz, J. E., Vance, E. F., Serebreny, S.
Stanford Research Institute, Menlo Park, California
Feb 65 2p
Report No: SR-1
Contract: AF19 628 3308
Project: 6020 4690
Task: 601003
Monitor: AFCRL-65-112

Abstract: The results of a cooperative effort by Stanford Research Institute, United Air Lines, and Air Force Systems Command to determine the correlation between regions of clear-air turbulence and aircraft electrical activity are described. Corona discharges from precipitation static dischargers on DC-8 aircraft were monitored and correlated with clear-air turbulence encounters. A significant correlation was found to exist between clear-air turbulence encounters and periods of electrical discharge. It is suggested that these electrical discharges may be caused by electric fields in the region of clear-air turbulence, particulate matter in the region that charges the aircraft, or a combination of both. (Author)

AD-613 035

STUDY PROGRAM ON PRECIPITATION STATIC DISCHARGE

LTV Electrosystems Inc., Greenville, Texas
AUTHOR: Nanevicz, J. E., Vance, E. F., Martin, J. A.
Descriptive Note: Final Report, Feb 67 58p
Contract: AF 33(657)-12407
Supplementary Note: Prepared in cooperation with Stanford Research Institute, Menlo Park, California, Project SRI-6293. DDC Form 55 not necessary for document request.

Abstract: Noise received in towel-bar antennas on operational flights of KC-135 aircraft is investigated. Laboratory measurements, in addition to an analytical study, indicate that the principal source of noise is streamering resulting from particle charging of the dielectric antenna masts. Antenna modifications--replacing dielectric masts with conducting or partially conducting masts--are recommended to eliminate streamering. Noise levels produced by corona discharges from aircraft extremities are shown to be considerably less than noise levels produced by streamering (unmodified antenna) and particle impact. Corona breakdown at towel-bar antennas is shown to be unlikely for either the unmodified antenna or a properly modified antenna.

THE RADIO EMISSIONS FROM CLOSE LIGHTNING

AUTHOR: Oetzel, George N., Pierce, Edward T.
Stanford Research Institute, Menlo Park, California
Feb 68 46p
Report No: Scientific Note-10
Contract: Nonr-4099(00)
Proj: NR-082 206, SRI-4454

Abstract: This survey considers the frequency range from below 1 KHz to above 10 GHz. At all frequencies the peak amplitude of the noise accompanying a single flash is examined. The structure and amplitude distribution of the separate pulses occurring within a complete discharge are investigated with particular reference to frequencies exceeding some 3 MHz. Among special topics discussed are the excitation of Schumann resonances, the generation of slow tail signals at frequencies less than 1 KHz, and the production of pulses at VLF (3-30 KHz) by return-strokes and other features of a lightning flash. Conclusions and recommendations for further work are given. (Author)

AD-666 711

SOME QUALITATIVE RESULTS ON THE ELECTRIFICATION OF SNOW

Canadian Journal of Research, issued by The National Research Council of Canada
AUTHOR: Pearce, D. C., and Currie, B. W.
Vol 27, Sec A.
Jan 1949 No. 1

Abstract: This paper reports on observations of the electrical charges on falling and drifting snow, and gives the results of laboratory experiments designed to determine the relative importance of possible charge-producing mechanisms in the atmosphere when snow and ice crystals are present. These mechanisms include impacts of snow particles on

one another, melting of snow as it falls, and condensation of water vapor and formation of rime on falling snow. Apparently a large fraction of the snowflakes falling during the cold part of the winter in Saskatchewan has a charge less than 2×10^{-4} e.s.u. per flake. During blizzards the snow particles blowing along or just above the hard surface of the drifted snow carry a net negative charge and the air at the 1 m. level has positive space charge densities that are from 10 to 100 times the normal, positive space charge density. Very large charge separations can occur when a snow surface is eroded by an air blast and when snow is blown against snow and metal surfaces, a resultant negative charge appearing on the heavier particles and the corresponding positive charge on either very small ice particles or ions. This charge-producing mechanism is most effective at high air velocities and at low temperatures. The melting of newly fallen snow under conditions favorable to the escape of air bubbles does not show a charge separation. Condensation of water vapor and formation of rime on snow surfaces result in only very small charge separations for the conditions readily obtained in laboratory experiments.

AN ANALYSIS OF CORONA-GENERATED INTERFERENCE IN AIRCRAFT

AUTHOR: Tanner, R. L., and Nanevicz, J. E.
Proceedings of the IEEE
Jan 1964, Vol 52, No. 1, 44p

PRECIPITATION CHARGING AND CORONA-GENERATED INTERFERENCE IN AIRCRAFT

AUTHOR: Tanner, R. L., Nanevicz, J. E.
Stanford Research Institute, Menlo Park, California
Contract AF 19(604)-3458

Abstract: *Triboelectric charging, occurring when an aircraft is operated in precipitation,* raises the aircraft potential until corona discharges occur from points of high dc field on the aircraft. These corona discharges generate noise which is coupled into receiving systems. The magnitude and spectral distribution of this radio interference, called "precipitation static", depends upon three factors: (1) the strength and spectral characteristics of the source discharges, (2) the manner in which the disturbances produced by the discharges couple into the antennas and (3) the magnitude of the discharge current and its distribution among the discharging extremities.

The coupling between the antenna and the noise source is discussed with the aid of a reciprocity relationship. Since the geometry of an aircraft is complicated, and a purely theoretical approach to the determination of coupling factors is not possible, a technique for measuring absolute values of coupling factor as a function of frequency and position on the aircraft was developed and is described in considerable detail.

A study was made of the spectral character of the corona-noise source. Included in this study was an investigation of the manner in which the source spectrum is affected by altitude. Since the noise spectrum magnitude depends upon the total current discharged, methods for determining the discharge current were devised. Furthermore, given a total discharge current, the noise generated in an antenna depends upon the distribution of this current among the various extremities. The problem of determining this distribution was investigated.

To test the validity of the theory and the results of the laboratory work, calculations were made to predict the noise currents induced in the two test antennas employed in a flight-test program conducted on the Boeing 367-80 aircraft (prototype of the KC-135 and 707). The results of these predictions are compared with the noise spectrum measured in flight.

ELECTROSTATIC CHARGING AND NOISE QUIETING

AUTHOR: Truax, R. L.
Air Force Avionics Lab, Soc. Automotive Engrs
1970 Lightning and Static Electricity Conference 157-73, 1971
9-11 Dec 1970 San Diego, California, USA
Publ: Air Forces Avionics Lab, Wright-Patterson AFB, Ohio

Abstract: A system approach was taken to identifying noise sources due to electrostatic charging. To measurement of charging levels, application of noise reduction techniques and flight test verification. Streamer currents to 40 microamperes were measured on plastic structural components, cross field stresses exceeding 100 KV/M were recorded and propellor corona currents were observed to exceed 50 microamperes per blade. Precipitation charging rates of 250 microamperes were encountered. One tip type discharger reached a 400 microampere discharge current on one occasion. Discharges of opposing polarities were observed from different aircraft extremities at the same time. A total discharge current of 2.5 ma was occasioned. Steps were taken to reduce noise generation when the aircraft became charged electrically. These included installation of quiet dischargers, conductive coating of plastic frontal surfaces and use of DC sealed antennas. Actual flight tests demonstrated that with proper application of corrective measures usable navigation and communications could be retained in the most severe conditions encountered. Without the corrective measures, communications and navigation, through the VHF spectrum, were lost for extended periods of time in actual flight.

EFFECTS OF LABORATORY SIMULATED PRECIPITATION STATIC ELECTRICITY AND SWEPT STROKE LIGHTNING ON AIRCRAFT WINDSHIELD SUBSYSTEMS

AUTHOR: Twomey, R. C.
Douglas Aircraft Company, Long Beach, California
Final Report Nov 75 - May 76
July 76 162p
Report No: MDC-J6952
AD-A037 196/3ST

THE INFLUENCE OF OXYGEN AND WATER VAPOUR ON THE PRO GATION OF BREAKDOWN STREAMERS IN AIR AS REVEALED BY THE LICHTENBERG FIGURE TECHNIQUE

AUTHOR: Waidmann, G.
California Univ Berkeley
6 Nov 62 10p
Rept No: TR82
Contract: Nonr22244
Project: NR012 201
Reprint from Dielectrics, 1:2, pp. 81-90, May 1963
Distribution limitation now removed. NOTE: Only 35mm microfilm is available. No microfiche.

Abstract: No abstract available.

AD-423 143/7ST

VLF AIRBORNE SYSTEM NOISE AND ANTENNA STUDY AND STUDY OF LANE IDENTIFICATION FOR OMEGA, VOLUME I

AUTHOR: Woodward, Richard H., Spears, Morton F., Ambroseno, Bernard, and Davidson, David
Continental Electronics Mfg Co., Waltham, Massachusetts, Pickard and Burns Electronics Division
Final Report
4 Mar 68 132p
Rept No: P/B-Pub-979-8
Contract: FA-65-WA-1298
Project: FAA-910-012-01N, SRDS-350-102-06N
Monitor: FAA-RD-68-17

Abstract: The immediate purposes of the program are to determine the effect of precipitation static on the reception in aircraft of very-low-frequency signals, to devise a method for reducing the effect to a tolerable level and to collect data on Omega, and ultimately to determine the feasibility of Omega for air navigation. Three types of airborne antennas have been investigated. Phase-difference and field-intensity data were collected over periods of approximately three days and three nights in winter and summer at six widely scattered monitor stations (airports) in South America and six in North America. This information is needed for the accurate prediction of Omega sky-wave corrections, hyperbolic lines of position and lane identification. For the study of the propagation of Omega signals at relatively short range from the transmitting station, phase difference of Omega signals relative to a stable reference source were measured in a small truck traveling along the highways out to a range of 600 kilometers from the Forestport station. (Author)

AD-675 504

INVESTIGATION OF GENERAL WIRE ANTENNAS

AUTHOR: Andreasen, Mogens, G., Tanner, Robert L.
Trg Inc., Melville, New York
Final Rept. May 66 - July 67
Aug 67 82p
Rept No: TRG-W-127-F
Contract: DA-28-043-AMC-02373(E)
Project: DA-1-P-620501-A-448
Task: 1-P-620501-A-44804
Monitor: ECOM-02373-F

Abstract: Integral equations for the current distribution on an arbitrary wire antenna have been programmed for a digital computer. The resulting computer program will calculate the current distribution, the input impedance, and the radiation pattern of a wire antenna of arbitrary geometry. Considered as a transmitting antenna, the antenna is excited by electromotive forces applied in any number of gaps along the wires. The program developed will permit these gaps to be connected by an arbitrary non-radiating network, and it will take into account resistive and reactive loading along the wires. The program will also treat the antenna as a receiving antenna, if desired, and then uses a distant dipole as the source of the induced current distribution. The numerical integral equation method used is essentially an exact method. The principal errors in the calculations arise in the numerical integration of the integrals in the integral equations, and these errors can be controlled. It is usually quite easy to obtain accuracies far better than normal measurement accuracies, and at a much lower cost.

AD-819 198/3ST

B. E-Field and H-Field VLF Antennas.

AIRCRAFT ANTENNAS

AUTHOR: Granger, J.V.N., and Bolljahn, J. T.
Proceedings of the I.R.E.
Vol. 43, No. 5, May 1955

FERRITE ROD ANTENNA ARRAYS FOR LORAN-C RECEIVERS

AUTHOR: Ikrath, Kurt
Army Electronics Command, Fort Monmouth, New Jersey
Technical Report
Jun 72 74p
Rept No: ECOM-3574
Project: DA-1-H-62701-A-448
Task: DA-1-H-62701-A-44806

Abstract: The use of a small ferrite antenna array is shown theoretically to be superior in performance to the whip antenna supplied with a PSN-4 Loran-C receiver manpack set. While the paper is overall theoretical in nature, the theoretical results and conclusions have been verified in subsequent limited experimentation. Initial test with a compact ferrite rod antenna array in place of a whip showed that the time for acquisition of Loran-C time coordinates with the PSN-4 set is reduced to about one third the time it takes with a 15 foot long whip. (Author)

INVESTIGATION OF A NOISE-CANCELLATION ANTENNA SYSTEM FOR AIRBORNE OMEGA

AUTHOR: Baltzer, O. J.
Tracor, Inc., Austin, Texas
November 1971

COMBINED MULTI-POLARIZATION LOOPSTICK AND WHIP ANTENNA

AUTHOR: Ikrath, Kurt and Acker, Morris
Department of the Army
Patent
Filed 1 Jun 71, patented 27 Feb 73
Rept No: PAT-APPL-148 755
Monitor: 18
This government-owned invention available for U.S. licensing and, possibly, for foreign licensing. Copy of patent available Commissioner of Patents, Washington, D.C. 20231 $0.50.

Abstract: A receiving antenna assembly for mitigating signal fading and cancellation caused by the degrading effects of multipaths and scatter in jungle, mountain or urban environments which antenna has three mutually-perpendicular, multi-polarization ferrite loopsticks for sensing H-field signal energy and a whip antenna for sensing E-field signal energy, and selection means for choosing amoung the signal energies sensed by the ferrite loopsticks and the whip antenna.

PATENT-3 718 932

A THEORETICAL TREATMENT OF LOW-FREQUENCY LOOP ANTENNAS WITH PERMEABLE CORES

AUTHOR: Islam, Mohammed Azizul
IEEE Transactions on Antennas and Propagation
March 1973, Vol. AP-11, No. 2, 162p

REDUCED SIZE VLF/LF COMMUNICATION ANTENNAS

AUTHOR: Lay, L.L.
1973 National Telecommunications Conference, A734199
Atlanta, Georgia 26-28 Nov 73
Institute of Electrical and Electronics Engineers
Papers in NTC '73 Conference Proceedings, 26 Nov 73
$25.00 IEEE mems and $20.00 non-mens: IEEE Order Dept.: 345 East 47 Street, New York, New York 10017

F-77

SCATTERING OF DIELECTRIC-LOADED SCREEN

AUTHOR: Lee, S.W.
University of Illinois, Urbana
IEEE Trans Antennas Propagation, V. AP-19, No. 5, Sept. 1971, p656-65

Abstract: A numerical solution for the problem of scattering of a plane wave by a dielectric sheet with an imbedded periodic array of conducting strips is presented. The primary motivation for introducing the strips is to reinforce the mechanical hardness of the sheet in certain radome applications. The study shows that with proper design the additional strips can also improve the electric transmission through the composite structure.

VLF LOOP ANTENNAS FOR PULSE RECEPTION

AUTHOR: Lidholm, Sverre U., Netzler, Goran, P. R.
Chalmers University of Technology, Gothenburg, Sweden
IEEE Trans Aerosp Electron System, V. AES-10, No. 2, March 1974, p211-215.

Abstract: This paper describes an approach to the realization of a VLF loop-type antenna system. The theoretical analysis is applied to a four-loop system for Loran-C reception.

DESIGN OF ELECTRICALLY SMALL BROADBAND RECEIVING ANTENNAS UNDER CONSIDERATION OF NONLINEAR DISTORTIONS IN AMPLIFIER ELEMENTS

AUTHOR: Lindenmeier, H. K.
International IEEE/AP-S Symposium and USNC/URSI Meeting
Institute of Electrical and Electronics Engineers; International Scientific Radio Union, (U.S. National Committee)
URSI Program and Abstracts, $5: R. Y. Dow, USNC/URSI, NAS, 2101 Constitution Ave., Washington, D. C. 20418. APS Conference Digest, $10 members, $15 others (Cat. No. 76CH1121-3AP): IEEE, 345 E. 47th Street, New York, New York 10017. A bound volume of papers on Biological Effects will be published after the meeting as a special issue of "Radio Science".

LOW-FREQUENCY AIRBORNE ANTENNA SYSTEM

AUTHOR: Maxwell, James C.
Airtechnology Corp., Cambridge, Massachusetts
Final Rept, 1 May - 30 July 64
30 Aug 64 59p
Rept No: 1
Monitor: 18
Contract: DA-02-086-AMC-0051(E)

Abstract: Efforts concern a study program to determine the optimum design and the fabrication requirements for a low frequency airborne antenna system. The system will be capable of operating in the frequency range from 30 to 300 KCS and will be used with airborne communication and navigational receiving equipments on a multiple or time-sharing basis. Various antenna systems were analyzed and evaluated in terms of specific design goals for a low-frequency navigation communication receiving antenna system for use on several types of U.S. Army aircraft, both fixed-wing and rotary. In addition to the design goals, the antenna systems were considered in relation to three specific factors--susceptibility to electrical noise environment, antenna polarization, and sensitivity. The effects of helicopter rotor-modulation on the antennas were studied. The preliminary engineering design of an airborne, omni-directional, 30-300 kc whip antenna with preamplifier, designed to obtain optimum electrical and aerodynamic performance, was completed. (Author)

AD-458 148

COUPLING EFFECTS ON ELECTRICALLY SMALL ANTENNAS ON AIRCRAFT

AUTHOR: Medgyesi-Mitschang, L. N.
McDonnell Douglas Res. Labs, McDonnell Douglas Corporation, St. Louis, Mo.
1977 IEEE International Symposium on Electromagnetic Compatibility, 166-71, 1977
2-4 Aug 1977, Seattle, Washington
Report Section

Abstract: An analytical technique, based upon the method of moments theory, is useful for predicting the coupling and interference of neighboring electrically small radiating structures, either active or passive, on a conducting body. This technique, implemented by a computer algorithm, predicts the distortive effect of the body on the gain characteristics of primary radiating elements. Examples are given for loop and monopole antennas coupled to helicopter fuselages. The analytical predictions are correlated with range measurements. (10 Refs)

LORAN ANTENNA STUDY FOR F4-D AND OV-10 AIRCRAFT

AUTHOR: Nanevicz, J. E., Chown J. B., and Priedigkeit, J. H.
Stanford Research Institute, Menlo Park, California
Contract: F19628-72-C-0128

Abstract: A study was made to define appropriate antennas and precipitation-static-protection requirements for the LORAN-D system being developed by Lear Siegler, Inc. Several antenna designs suitable for all-attitude aircraft operation were considered and are described. The tradeoffs associated with each antenna type are discussed. The results of a short precipitation-static study are included, along with recommendations regarding precipitation-static-alleviation procedures that must be followed to permit noise-free LORAN-D operations under all weather conditions.

SOME TECHNIQUES FOR THE ELIMINATION OF CORONA DISCHARGE NOISE IN AIRCRAFT ANTENNAS

AUTHOR: Nanevicz, J. E., and Tanner, R. L.
Proceedings of the IEEE
January 1964, Vol. 52, No. 1, p53

CONSIDERATIONS ON THE DIMENSIONING OF FERRITE ANTENNA AMPLIFIERS IN THE VLF REGION

AUTHOR: Nessler, N.
Feb. 1969 - Mar 1969
cn f 61052-69-C-0007

Abstract: For the reception of VLF waves, ferrite rod antennas are used which are normally coupled with the preamplifier input via a transducer. Relations are derived which permit the optimum dimensioning of antenna inductance and transducer in order to attain as high as possible a signal voltage. The noise behavior of the input stage is taken into consideration in a suitable adaptation.

RIGOROUS COMPUTATION OF RADIATION FIELDS OF VLF/ELF ANTENNAS ON EARTH'S SURFACE

AUTHOR: Nunn, D.
17th Plenary Meeting of Committee on Space Research 8742056, Sao Paulo, Brazil, 20-28 Jun 74
Committee on Space Research
Papers (Eng and Fr) in "Space Research XV" and in "Life Sciences and Space Research XIII", May 75: Akademie-Verlag, Berlin, Germany (Fr). Papers (Eng and Fr) from the Symposium on Satellite Dynamics in separate proceedings volume, May 75: Springer-Verlag, Berlin, Germany (Fr). Abstracts (Eng and Fr) in program, 17 Jun 74; inquire: Mr. Z. Niemirowicz, COSPAR, 55, Boulevard Malesherbes, 75008 Paris, France.

F-77

TAIL CAP AND FERRITE CROSSED LOOP ANTENNA MOUNTED ON AIRCRAFT

Pickard and Burns Electronics Division, Continental Electronics Mfg. Co.
August 1968

VLF AIRBORNE SYSTEM NOISE AND ANTENNA STUDY AND STUDY OF LANE IDENTIFICATION FOR OMEGA, VOLUME I

Pickard and Burns Division, Continental Electronics Mfg. Co. for Federal Aviation Administration

Abstract: The immediate purposes of the program are to determine the effect of precipitation static on the reception in aircraft of very-low-frequency signals, to devise a method for reducing the effect to a tolerable level and to collect data on Omega, and ultimately to determine the feasibility of Omega for air navigation.

Three types of airborne antennas have been investigated. The long-wire antenna was abandoned early in the program because it was not notably superior electrically and was aerodynamically unsuitable. Each of three 24-inch blade antennas performed well except in wet weather. Two pairs of crossed-loop antennas demonstrated least sensitivity to precipitation static and rain. These are preferable aerodynamically for high speed aircraft but for navigation systems require complicated switching. Locations of the blade and crossed-loop antennas on the aircraft are not critical.

Plans to collect data in subsonic and supersonic jet aircraft ultimately had to be abandoned because appropriate aircraft could not be provided.

Phase-difference and field-intensity data were collected over periods of approximately three days and three nights in winter and summer at six widely scattered monitor stations (airports) in South America and six in North America. This information is needed for the accurate prediction of Omega sky-wave corrections, hyperbolic lines of position and lane identification. For the study of the propagation of Omega signals at relatively short range from the transmitting station, phase difference of Omega signals relative to a stable reference source were measured in a small truck travelling along the highways out to a range of 600 kilometers from the Forestport station.

RADOME TECHNOLOGY. (CITATIONS FROM THE ENGINEERING INDEX DATA BASE)

AUTHOR: Reed, William E. (Ed.)
NTIS, Springfield, Va
NTISearch NTIS/PS-77/1153/4ENS, Search Period Covered 1970 - Nov 1977. Published by NTIS, Springfield, Va., Dec 1977. Available from Eng Index, New York, New York, or NTIS 95p CODEN: NTISDZ.

Abstract: Papers from worldwide literature are cited on the use of composite materials, ceramic materials, plastics, dielectrics, and protective coatings for radomes. Research on design, construction, and fabrication is included. Performance evaluations are presented which cover wave transmission, insertion loss, effect of antenna radiation patterns, rain erosion, and impact resistance. This updated bibliography was prepared by searching the 1980-November 1977 data base of Engineering Index. It contains 95 abstracts, 19 of which are now entries to the previous edition.

OPTIMIZATION OF RECEIVING LOOP ANTENNAS WOUND ON A CYLINDRICAL FERRITE CORE

AUTHOR: Simpson, T. L.
University of South Carolina, Columbia.
1977 International Institute of Electrical and Electronics Engineers Antennas and Propagation Society Symposium/International Scientific Radio Union United States National Committee Meeting/International Scientific Radio Union International Electromagnetic Symposium A772096 Palo Alto, California 20-24 June 1977.
International Institute of Electronics Engineers (Antennas and Propagation Society); International Scientific Radio Union (United States National Committee; International Electromagnetic Symposium).

PRECIPITATION PARTICLE IMPACT NOISE IN AIRCRAFT ANTENNAS

AUTHOR: Tanner, Robert L.
IRE Transactions on Antennas and Propagation
April 1957, Vol. AP-5, No. 2, 232p

THE COMPUTER-AIDED DESIGN OF LF, MF AND HF ANTENNAS

AUTHOR: Wharton, W.
Tech. for Communications International Ltd., UK
International Conference on Antennas and Propagation, 7842269 London, United Kingdom, 28-30 Nov 78.
Institute of Electrical Engineers (Electronics Division); Institute of Electrical and Electronics Engineers (Antennas and Propagation Society); Institute of Mathematics and its Applications; Institute of Physics; Institution of Electronic and Radio Engineers; International Union of Radio Science.
Papers in "IEE Conference Publication No. 169; Parts 1 and 2; Antennas and Propagation" (ISBN 0 85296195 2) in Eng, 30 Nov 78; IEE, Publication Sales Dept., P.O. Box 26, Hitchin, Herts SG5 1SA, UK.

C. Aircraft Dischargers and Anti-Static Coatings.

FABRICATION AND TESTING OF AN ACTIVE ELECTROSTATIC DISCHARGER SYSTEM FOR THE CH-47 HELICOPTER

AUTHOR: de la Cierva, Juan, Fraser, David B., Wilson, Paul B., Jr.
Dynasciences Corp., Blue Bell, Pennsylvania
Oct 67 67p
Rept No: DCR-224B
Contract: DA-44-177-AMC-114(T)
Task: 1F121401A14130

Abstract: Numerous incidents of severe shock to ground personnel and potential hazards to cargo during external sling load cargo operations have led to extensive research efforts aimed at the dissipation of high electrostatic energy levels present on helicopters. The Model D-03 Electrostatic Discharger is essentially a closed-loop servo system. The report covers its fabrication, mechanical evaluation, environmental testing, and flight testing under both arctic and dusty/high-humidity conditions. Drawings and photographs are included in the report as an aid to a thorough understanding of the system.

AD-664 201

THEORETICAL ANALYSIS OF AIRCRAFT ELECTROSTATIC DISCHARGE

AUTHOR: de la Cierva, Juan, Gillis, Herbert J., Wilson, Paul B., Jr.
Dynasciences Corp., Fort Washington, Pennsylvania
Final Report for June 63 - Jan 64
Aug 65 2p
Rept No: DCR-132
Contract: DA44 177AMC82T
Task: 1P121401A14130

Abstract: The general problem of aircraft electrostatic charging and one of the more efficient discharger systems presently available are discussed. Methods of discharger system design and analysis are developed and stated for this system. These methods are incorporated into design curves and other data to facilitate and optimize design. The problem of efficient discharge corona electrode design is treated extensively. With the information on corona developed in the report, it becomes possible to include the corona electrode in the system design using conventional engineering design methods. Data permitting optimization of corona electrode performance, that is, current maximization at a given electrode voltage is given. The effects of aircraft altitude are significant on electrode operation. Numerous approaches to the reduction of system voltage requirements are discussed. (Author)

AD-621 521

CONDUCTIVE TRANSPARENT THERMOPLASTIC FILMS

AUTHOR: Custis, I. H.
Naval Air Engineering Center, Philadelphia, Pennsylvania, Aeronautical Materials Lab (245820)
Progress Rept No. 2, 1 July 65 - 30 Jun 66
30 Jun 66 2p
Project: NABC-AML(38)R-360
See also AD-473 193

Abstract: Progress in developing conductive transparent thermoplastic materials by using internal antistatic agents, is reported. A test procedure for evaluating the electrostatic properties was developed and is described. (Author)

AD-640 273

ELECTROCONDUCTIVE POLYMERS

AUTHOR: Dolinski, R. J., Dean, W.R.
Dow Chemical Co., Midland, Michigan
Chem Tech May 1971 p304-9

Abstract: Electroconductive polymers are an important class of macromolecules whose major application is in electrophotography. Papers made conductive with certain of these resins exhibit surfcce electrical conductivity three to four orders of magnitude higher than untreated paper. The conductive polymers are thought to be ionic rather than electronic conductors and they provide water holding capacity, especially at low relative humidities. Conductivity varies with temperature, resin molecular weight, and nature of the counter ions in both cationic and anionic polymers. The most commonly used polyelectrolyte is one based on polyvinylbenzyltrimethyl ammonium chloride. The conductive polymers show promise in their reprographic processes such as in electrographic printing, and as antistatic agents, conductive coatings, electroplating, flocculants, and filtering aids. (17 refs.)

ROTOR BLADE TREATMENTS TO MINIMIZE ELECTROSTATICALLY GENERATED NOISE ON THE HLH HELICOPTER

AUTHOR: DeRosa, R., Solak, J.
Boeing Vertol Co., Philadelphia, Pennsylvania
1 May 74 67p
Rept No: D301-10279-1
Contract: DAAJ01-73-A-0017

Abstract: A laboratory investigation was undertaken to evaluate the severity of precipitation-static noise to be expected on the Heavy Lift Helicopter (HLH) low-frequency systems, and to define the requirements of techniques for noise elimination on the HLH. This investigation, using a 1/25th scale model of the HLH and actual proposed rotor-blade panel samples revealed the need for RFI protection on the HLH. Recommendations were made to install P-static dischargers on the HLH rotor blades, and the optimum number and location of these dischargers was discussed. Noise reduction afforded by various rotor-blade-coating systems was also investigated and reported. A recommendation was made for a particular coating system, based on noise-reduction and surface-resistivity measurements. (Author)

AD-780 720/9

INVESTIGATION OF CH-54A ELECTROSTATIC CHARGING AND OF ACTIVE ELECTROSTATIC DISCHARGER CAPABILITIES

AUTHOR: Becher, Michael C.
Dynasciences Corp., Blue Bell, Pennsylvania, Scientific Systems Division
Final Rept
Jan 70 100p
Rept No: DCR-304
Contract: DAAJ02-69-C-0102
Project: DA-1-X-163203-D-332

Abstract: A test program was conducted at Yuma Proving Ground, Arizona, to obtain inflight measurements of electrostatic charging rates experienced by a CH-54A helicopter operating in a dusty environment and to evaluate active electrostatic discharger systems as solution techniques. This report presents data obtained during this program and reviews these data along with those from previous work on the same aircraft type. This report concludes that an extremely high and possibly lethal charge level is present on the CH-54A in the operational hookup situation, that an active discharger system capable of discharging 200 microamperes is required to dissipate this charge, and that, while presently available equipment does not meet this requirement, repackaging of present hardware offers a probable solution. (Author)

AD-865 988/OST

LORAN-D ELECTROSTATIC RFI AND NULL FIELD DISCHARGER FLIGHT TESTS

Granger Associates
January 1967

METHOD OF MINIMIZING ACCUMULATION OF ELECTROSTATIC CHARGE ON POLYETHYLENE

AUTHOR: Block, Burton P., Sprout, Oliver S. Jr., Dahl, Gerd H.
Department of the Navy, Washington, D.C.
Patent
Filed 3 Jun 70, patented 16 May 72 2p
Rept No: PAT-APPL-43 178; PATENT-3 663 274
Monitor: 18
Government-owned invention available for licensing. Copy of patent available Commissioner of Patents, Washington, D.C. 20231 $0.50.

Abstract: The patent describes the use of poly (metal phosphinates) as electrostatic discharge agents on polyethylene and other polymeric surface materials. More specifically, zirconium dihydroxy dibutylphosphinate dioctylphosphinate and chromium aquo hydroxy dibutylphosphinate and/or chromium aquo hydroxy methylphenylphosphinate are deposited from a solvent such as chloroform to provide an antistatic coating on the polymeric material.

AD-164 185/1

EMERSON AND CUMING, INC. (Sales Promo)

Eccocoat 256 and 257, carbon based semiconductive lacquers for use where the conductivity of silver based lacquers is not needed, can be brushed or sprayed. Eccocoat 256 surface resistance of 100-200 ohms per square. Eccocoat 257 surface resistance of 6-10 ohms per square.

Eccocoat 258A is an elastomeric version of Eccocoat 257. Surface resistance is a function of tension on the surface, increasing as the film is stretched. Resistance is 100-120 ohms per square.

Eccocoat 341 moderately conductive silver epoxy resin. A coating of 0.008" has a surface resistance of 0.3 ohms per square.

CONTROLLED HELICOPTER DISCHARGE

AUTHOR: Buser, Rudolf, G., Kaunzinger, Helmuth M., Gumeiner, Irwin
Army Electronics Command, Fort Monmouth, New Jersey
Research and Development Technical Rept
May 72 38p
Rept No: ECOM-3575
Project: DA-1-T-061102-B-31-A
Task: 1-T-061102-B-31-A-01

Abstract: Several new approaches, potentially capable of discharging a helicopter to an operationally safe potential against ground, have been explored. Specifically, water spray discharges have been studied under various conditions and appear promising. Other elements of a complete active discharge system, namely, field sensor and information processor/indicator, have been developed and tested also, as well as the complete system itself. (Author)

AD-745 102

INVESTIGATION OF REINFORCED PLASTICS FOR NAVAL AIRCRAFT ELECTROMAGNETIC (E-M) WINDOWS

AUTHOR: Chase, Vance A., Stander, Maxwell
Whittaker Corp, San Diego,
California
Pac Tech Conf and Tech Disp (PACTEC '75), 1st Annual Proc, Las Vegas, Nevada, Sep 16-18 1975, p161-167. Sponsored by SPE, West Sect (Adv in Plast Technol, 1st Annual), Greenwich, Conn, 1975

Abstract: This is a report on an experimental investigation in which dielectric and mechanical properties of various fiber-reinforced polymers were evaluated in regard to their applications in aircraft radomes. Primary emphasis was on polybutadiene polymers, with various other classes of polymers including thermoplastics being investigated as secondary candidates. A survey was conducted on the availability of polybutadiene polymers and a characterization study performed on 14 different resins from three manufacturers. A study was conducted into the type of contaminants contained in polybutadiene resins and their effect on electrical properties. Primary candidate fiber reinforcement materials were Astroquartz and Kevlar 49. Investigations were conducted into fiber finishes and surface treatments compatible with the polybutadiene resin for both fiber reinforcements. Efforts towards upgrading the toughness and adhesion characteristics of the polybutadiene were performed. Mechanical and electrical properties of the composite materials were determined both before and after humid aging and versus temperature. It is demonstrated that the polybutadiene/Astroquartz material was superior, from an overall standpoint, for radome applications of any of the materials investigated. Particularly impressive were dielectric properties and their stability versus frequency, temperature, and after humid aging. Extensive test data are included. (7 refs.)

EVALUATION OF A HELICOPTER-FUSELAGE MOUNTED DYNAMIC-NEUTRALIZER STATIC ELECTRICITY DISCHARGING SYSTEM

AUTHOR: Cierva, Juan de la
Kellett Aircraft Corp, Philadelphia, Pennsylvania
Rept for Jan - Jul 62
Dec 62 2p
Contract: DA44 177TC843
Task: 1D121401A14130

Abstract: A static electricity discharging system, known as the dynamic neutralizer, has been designed, built and flight tested, and the results are presented herein. The dynamic neutralizer had been previously tested in a rotor-blademounted version as reported in a previous report (AD-406 212). The program discussed in the present report was concerned with the evaluation of this discharger when installed in the fuselage of an Army H-37 helicopter. The test data confirm that the principle of operation of the dynamic neutralizer is not affected by locating the entire device in the fuselage. The dynamic neutralizer utilized in this program was tested with generator voltages up to 60 kilovolts. With this voltage, the H-37 helicopter, operating under the natural charging conditions prevailing at the test site, was discharged to a minimum energy level of 3.4 millijoules from the estimated 1000 millijoules present in the helicopter before the discharger was put into operation. It appears, however, that better performance will be required for operational purposes. It is recommended, therefore, that further research be conducted toward achieving the required performance. (Author)

AD-609 053

DURABLE ANTISTATIC COATING FOR POLYMETHYLMETHACRYLATE

AUTHOR: Hadek, V., Rembaum, A., Somoano, R. B.
National Aeronautics and Space Administration, Pasadena Office, California
Patent Application
Filed 3 Jun 76 13p
Rept No: PAT-APPL-692 284; NASA-CASE-NPO-13867-1
Contract: NAS7-100
This government-owned invention available for U.S. licensing and, possibly, for foreign licensing. Copy of application available NTIS.

Abstract: A durable antistatic coating was achieved on polymethyl methacrylate plastic without affecting its optical clarity by applying to the plastic surface a low molecular weight solvent having a high electron affinity and a high dipole moment. The solvents were acetonitrile, nitromethane, or photopolymerizable monomer. The treated polymethylmethacrylate plastic then dissipated most of the induced electrostatic charge and retained its optical clarity. The antistatic behavior persisted after washing, rubbing, and vacuum treatment.

N77-22257/8ST

POLYCARBONATE MOULDINGS WITH ASTATIC COATINGS

AUTHOR: Heynemann, Carl and Gonzales, Arturo
Agfa-Geraert, Munich, Ger
Kunstst Ger Plast, v 69, n 3, Mar 1979, p 4-5 CODEN: KSGPA7

Abstract: By astatically coating thermoplastic articles which cannot be given an antistatic finish by incorporating an antistatic agent into the molding compound, electrostatic charges can be prevented or dissipated. Several tests in this direction have already been carried out on polycarbonate moldings. Since polycarbonate is widely used as an insulating material in electrical engineering applications, astatic coating can be used where there are problems with electrostatic charging. For figures see German text.

DISCHARGE DEVICE FOR ELECTROSTATIC CHARGES

AUTHOR: Ikrath, Kurt and Murphy, Kenneth J.
Department of the Army
Patent
Filed 4 May 71, patented 15 May 73
Rept No: PAT-APPL-140 171
Monitor: 18

Abstract: This disclosure relates to aircraft and particularly to devices for reducing the triboelectric or electrostatic charge on an aircraft. More particularly, this disclosure relates to a device for penetrating the gaseous dielectric insulation around an aircraft to discharge the accumulated charge on said aircraft. More particularly, this disclosure relates to the projection of a stream of conductive gases, at high velocity, through the air surrounding an aircraft, towards ground or any point of high potential gradient with respect to the aircraft, to provide a conductive discharge path through the air to neutralize any electrostatic charge on the aircraft.

PATENT-3 733 038

ZELEC AS AN ANTISTATIC, FLAME-RETARDANT ADDITIVE - PRELIMINARY INVESTIGATION

AUTHOR: Lipscomb, Charles A., Muessig, Clifford W.
Naval Ammunition Depot Crane, Indiana (247250)
7191A2 Fld: 13L, 11G, 19A, 941, 920, 936 USGRDR7005
25 Aug 69 16p*
Rept No: NAD-CR-RDTR-154

Abstract: Plastics, in general, are relatively poor conductors of static electricity which tends to build up on the surface. The report indicates that Zelec (a phosphorus derivative of a long chain alcohol) may be formulated with a urethane resin to give antistatic and flame-retardant properties to the foamed-in-place material. (Author)

Descriptors: (*Expanded plastics, *Fire resistant materials), Isocyanate plastics, Static electricity, Organic phosphorus compounds, Alcohols, Additives).

AD-699 500 CFSTI Prices: HC A02/MF A01

ANTISTATIC COATINGS FOR THE PLASTIC NOSE CONES OF ARTILLERY FUZES

AUTHOR: Lee, Sheng Yen and Bruce, Keith C.
Harry Diamond Labs., Adelphi, Maryland
Technical memo.
Dec 78 29p
Rept No: HDL-TM-78-28

Abstract: Two antistatic coating formulations have been developed at the Harry Diamond Laboratories for the plastic nose cones of artillery fuzes. Both are conductive carbon-filled epoxy compounds. Formulation HDL900-3, developed in 1972, uses 2-ethyl-4-methylimidazole (EMI-24) as the curing agent. Formulation HDL900-6, developed as an alternative, uses m-phenylenediamine as the curing agent. Thermal stability, resistivity, and durability are the main criteria used to evaluate the formulations. The EMI-24 is of industrial grade. Its method of analysis and spectral data are recorded. (Author)

AD-A063 877/5ST

MERIX NO. 79 CONCENTRATE (Sales Promo)

Stops static and removes electrostatic charges on all types of hard surfaced plastics--acrylics, polystyrenes, vinyl, thermoplastics, and thermosets. No. 79 acts as a non-metallic conductive coating. This can be brushed or sprayed on, can also be mixed with water-based paints and/or coatings.

METEX MA-509 (sales promo)

Description: METEX MA-509 is an RTV silicone adhesive filled with electrically conductive metal powders. Filler content is 87.5% by weight. Fillers are either a combination of pure silver and silver/copper composites, or oxidation - resistant copper. It is intended for EMI/RFI shielding and for bonding Xecon materials in EMI/RFI shielding applications. MA-509 is available in three package quantities: 74cc. Cartridge- Fits standard adhesive guns. 30cc. Syringe - Can be used with its own plunger, or may be attached to commercially available micro-air dispensers. 7.7cc. Tube - Recommended for small applications and limited requirements.

Typical Properties: Vehicle: Silicone RTV (non-acetic acid type)
Filler: A - Pure silver and silver-copper composites, B- Oxidation resistant copper
Tack Time: 2-4 hours
Cure Schedule: 1 to 4 days at room temperature depending on relative humidity and width of bond. Not recommended for bonds wider than $\frac{1}{2}$" (12.70 mm). Cures in the presence of moisture.
Cured Density: 4.4 gr/cm^3
Resistivity: .01 ohm-cm maximum
Lap Shear Strength: 125 Psi (8.78kg/cm^2)
Nature of Failure: At bond interface. MA-509 cohesive 100%
Storage Life: Cartridge and Tube: 120 days at room temperature if maintained in dry storage atmosphere. 30cc Syringe: 30-day shelf life due to the nature of the syringe seal.

RF MEASUREMENTS OF ELECTROSTATIC DISCHARGES PRODUCED BY TRIBOELECTRIC CHARGING OF NON-METALLIC STRUCTURE

AUTHOR: Clifford, D., Munsell, M.
McDonnell Aircraft Co., St. Louis, Mo
IEEE Electromagn Compat Symp Rec 19th, Seattle, Wash, Aug 2-4 1977.
Publ by IEEE (77CH1231-0 EMC), New York, NY, 1977.
Available from IEEE Serv Cent, Piscattaway, NJ p 228-231
CODEN: IECSBD

Abstract: Results are presented of a program designed to evaluate the effects of electrostatic charge buildup on nonmetallic thermal protection systems (TPS) of the type used for spacecraft heat shields. A representative array of ceramic tiles was electrostatically charged by a stream of particles from a newly designed blown-dust generator built around a dry nigrogen gas supply. The new generator design produced a reliable controlled stream of particles which, for the first time, allowed the RF radiation generated by electrostatic discharges to be accurately measured and analyzed.

NEW POLYMER RESEARCH AND DEVELOPMENT PROGRAM

AUTHOR: Nadler, C., Custis, I., Stallings, L.
Naval Air Engineering Center Philadelphia Pa Aeronautical Materials Lab
Progress rept.
1 Feb 67 42p
Rept No: NAEC-AML-2571

Abstract: Studies on poly (metal phosphinate) and silicone-carborane (SiB)polymers were directed toward the development of antistatic compositions; high temperature and fluid resistant elastomers and aircraft protective coatings; and multipurpose thickeners for high temperature greases. Potential exists for obtaining materials with -100 to 800F service capability. Water repellent, transparent hydroxyaquochromium methylphenylphosphinate antistatic coatings were produced which approached practical performance requirements. A hydroxyaquochromium methylphenylphosphinate--dioctylphosphinate copolymer thickening agent with E.P. properties successfully formed silicone, diester and polyester greases. New fluorocarbon phosphinic acid intermediates were synthesized directed toward improving the metal phosphinate polymer thermal stability and fuel resistance. A new series of flexible to rigid crosslinked chromium phosphinate polymers (m.p. > 500C) were produced which may provide the basis for high temperature aircraft coating. Limited studies on the silicone-carborane (SiB) elastomer family compounded with antioxidants indicate outstanding thermal stability in the 700 - 900F range. Improvement in physical strength is needed

AD-654 899

ELECTROMAGNETIC WINDOWS

AUTHOR: Poulos, N.
Georgia Inst of Tech Atlanta Engineering Experiment Station
Symposium on Electromagnetic Windows, Proceedings. Volume I.
Materials Research, Development, Testing and Evaluation. Part I and Part II
June 68 284p
Contract: F33615-67-C-1594
Project: AF-4161
Task: 416103
Monitor: AFAL-TR-68-97-Vol-1
See also Volume 2, AD-841 563

Abstract: Contents: Antenna windows for hypersonic and reentry vehicles; Ballistic impact resistance of silica radomes; Single impact studies of rain erosion mechanisms; Electrical design of the C5A nose radome; Missile radome protective covers; Dual mode radome materials research; Fiber reinforced ceramic electromagnetic windows; A thermal analysis of an ablating electromagnetic window; Phosphate nucleated glass ceramic radomes; Mechanical behavior of ceramics; Precision measurement of radome performance; Development of the radome for the Concorde prototype aircraft; X-band dielectric constant of slip cast fused silica; Characterization of fused silica slips; and Development of high-purity silica radome structures.

AD-841 562/2ST

SIMCO CO STATIC ELIMINATORS (Sales Promo)

Ionizing Air Guns and Air Nozzles: Compressed-air guns and nozzles have built-in static eliminator for simultaneous cleaning and neutralizing, or separating sheets of pile. Dust reattraction is prevented. Nozzles supplied individually, or in series along air header. Available standard or shockless, also light-free versions. Operation on house compressed air.

Induction: Grounded neutralizers reduce high charges to below spark or shock level. No power unit required.

One-Point: For neutralizing widely spaced narrow webs or trim, etc. In $\frac{5}{8}$" and $1\frac{1}{4}$" diameters.

TECHNOLOGY DEVELOPMENT REPORT: RESULTS OF STATIC ELECTRICITY DISCHARGE SYSTEM TESTS (ACTIVE AND PASSIVE) - HEAVY LIFT HELICOPTER

AUTHOR: Solak, John B., Wilson, Gregory J.
Boeing Vertol Co Philadelphia Pa Army Air Mobility Research And Development Lab., Fort Eustis, Va.
Final rept.
C344513 Fld: 1C, 13L, 51C, 94H, 51B GRAI7422
May 74 235p
Rept No: T301-10194-1; T301-10194-2
Contract: DAAJ01-71-C-0840

Abstract: The document presents the findings of a three-phase program consisting of laboratory tests, ground tests, and a full-scale flight test program to evaluate methods for active dissipation of the static Electricity buildup on the Heavy Lift Helicopter (HLH). Remote helicopter-borne electric field mills were also evaluated as sensors of the electrical potential between the hovering helicopter and the ground. Flight tests were conducted on a CH-47 helicopter, since the HLH is currently in its development stage. This document also presents the final results of the static electricity drainage tests for the Heavy Lift Helicopter (HLH) Advanced Technology Component (ATC) development program. (Modified author abstract)

AD-784 130/7

ANTISTATIC COATINGS FOR POLYMETHYLMETHACRYLATE

AUTHOR: Tr imov, N., Gershtein, L., Eremina, I.
Sov Plast n 7 1973 p 63-64

Abstract: The investigation relates to the dependence of the surface resistivity and translucency of PMMA specimens on the polysilicic acid content of the antistatic film, on the molar ratio of H//20 to SiCl//4 in the film-forming solution, on the time of maturation of the solutions, and on the SiCl//4 content (reckoned as SiO//2) of the solutions. 5 refs

D. *Measurement Devices and Methods.*

A TRANSISTORIZED ELECTROSTATIC FIELD METER

AUTHOR: Buckingham, J.H.
New Zealand. Dept. of Scientific and Industrial Research,
Wellington. Physics and Engineering Lab.
4352G1 Fld: 14B, 9C STAR0606
May 67 18p
Rept No: TN-198

N68-15658

TRIBOELECTRIC CHARGING OF AIRCRAFT DIELECTRIC SURFACES IN THE MICROWAVE FREQUENCY REGION (1-4 GHz)

AUTHOR: Cummings, Larry E.
Air Force Avionics Lab Wright-Patterson AFB Ohio
Technical Rept
C757113 Fld: 1C, 20N d7624
Oct 70 41
Rept No: AFAL-TR-70-137
Project: AF-4357
Task: 435706

Abstract: Triboelectric charging can cause serious problems to modern aircraft. This work effort attempts to determine the RF spectral content of streamers produced on various dielectric materials that are being used or could be used on future high performance aircraft. These values are found to be in good agreement with the theoretically derived spectrum. This investigation covered the frequency range of 1.0 GHz to 4.0GHz. Such a range is convenient in that it starts where other researchers have stopped and gives a good indication of expected signal levels at higher frequencies. A more detailed study could also be conducted due to the small frequency span. The first part of this report descusses the experimental setup and the rationale for the procedures used. Based on the experimental values obtained, definite recommendations are made for the reduction of precipitation static interference. The values obtained show a close correlation with flight test data. (Author)

AD-879 684/9ST

THE DESIGN, TEST AND EVALUATION OF A MINIATURIZED ELECTRIC FIELD METER

AUTHOR: Evans, J.E.; Velkoff, H.R.
Ohio State Univ Research Foundation Columbus
Interim technical rept.
A5365G2 Fld: 14B, 73D GRA17223
Jul 72 125 p
Rept No: TR-13
Contract: DA-31-124-ARO(D)-246
Project: DA-2-0-015501-B-700
Monitor: AROD-4942: 18-E

Abstract: The principle of operation of a field mill is explained and analytical analysis of the fixed conductor field mill is presented. Several previous field mill designs are reviewed, and the summary presents the different field mill designs in tabular form. A fixed conductor field mill is designed to operate in a subsonic wind tunnel whose airstream contains a particulate suspension. Various field mill vane configurations are designed, calibrated, and evaluated with the configuration best suited to the environment used to obtain measurement of the magnitude and polarity of the electric field in the wind tunnel. (Author)

AD-750 148

ELECTRICAL FIELD CHANGE METER

AUTHOR: Few, Arthur A.
Department of the Navy Washington D.C. (11050)
Patent
D2724B3 Fld: 4A, 14B, 55D, 90G GRA17716
Filed 29 Apr 74, patented 11 Nov 75 4p
Rept No: PAT-APPL-465 042; PATENT-3 919 636

Abstract: An improved electrical field change meter comprises the improvement of a capacitor being provided, that may be used during severe weather conditions, such as rainstorms, wherein the dielectric constant between the plates, air, is not affected by severe conditions. This is obtained by providing hemispheric shaped condenser plates, one mounted inside the other, and spaced therefrom by insulating standoffs. The entire condenser assembly is sealed to its based member to provide a weatherproof container for the electronic package. (Author)

AD-D003 744/ 0ST

STUDIES AND EXPERIMENTAL INVESTIGATION OF SPACE CHARGE MEASUREMENT EQUIPMENT

AUTHOR: Fluegge, Robert A.; Pilie, Roland J.
Cornell Aeronautical Lab Inc Buffalo N.Y.
Final rept. for 1 Sep 62-28 Feb 65
28 Feb 65 2p
Rept No: CAL-RM-1751-P-1
Contract: AF19 628 1680
Project: 8620
Task: 862001
Monitor: AFCRL 65-209

Abstract: Airborne instrumentation was developed to measure the electrical charge on individual raindrops; simulataneous drop size measurement can be correlated to each charge determination. The equipment is sensitive to charges ranging from =1.5 x 10 to the 6th power to =2.5 x 10 to the 9th power electronic charges on raindrops having diameters larger than 250 microns. A self calibrating, servo-controlled disdrometer is incorporated to insure that size and charge determinations are performed using drops that have not approached any solid surface. (Author)

AD-615 456

A NEW NEAR-ZONE ELECTRIC FIELD-STRENGTH METER

AUTHOR: Greene, Frank M.
National Bureau of Standards, Washington D.C.
Technical note
3063B2 Fld: 14B, 20C USGRDR6707
15 Nov 66 53p

Abstract: The National Bureau of Standards has recently completed the development of prototype instrumentation for measuring the electric-field components of complex, high-level, near-zone electromagnetic fields from 0.1 to 1000 volts per meter, at frequencies from 150 kHz to 30 MHz with a present uncertainty of less than plus or minus 2 dB. The design of the NBS meters is based on the use of a novel form of telemetry, employing a completely non-metallic electrical transmission line, which apparently has not been fully exploited heretofore. This avoids the perturbing effects on the field being measured, usually caused by field-strength meters employing metallic RF transmission lines. The design and performance of the meter are discussed in some detail. (Author)

NBS-TN-345

MICROCOMPUTERIZED ELECTRIC FIELD METER DIAGNOSTIC AND CALIBRATION SYSTEM

AUTHOR: Holley, L.D., Mason, J.W.
National Aeronautics and Space Administration, John F. Kennedy Space Center, Cocoa Beach, Fla

Patent Application
D2804U1 Fld: 14B, 90G STAR1511
Filed 24 Mar 77 14p
Rept No: PAT-APPL-780 874; NASA-CASE-KSC-11035-1

Abstract: A method for rapid calibration of field meters used to measure electromagnetic field potential is described. A reference voltage is applied to the field meter for causing signals to be produced on the output terminals thereof. A bank of relays is provided for selectively connecting output terminals of the field meter to a multiplexer by means of a digital voltmeter and an oscilloscope. A frequency-shift-keyed receiver is also connected to one of the terminals of the field meter for transmitting and converting a frequency shift keyed signal to a digital signal which is, subsequently, applied to the multiplexer. A microprocessor generates coded command signals to the bank of relays and also to the multiplexer for controlling the comparison of the output signals with information stored within the microprocessor.

N77-20343/8ST

AN OPERATIONAL FLIGHT TEST EVALUATION OF A LORAN-C NAVIGATOR

AUTHOR: Hughes, M. and Adams, R.J.
Systems Control, Inc. (Vt), Palo Alto, Calif. 94304
Final Rept, March 1977
Rept No: CG-D-9-77
Contract No: DOT-CG-63154-A

Abstract: This report presents the results of an operational test and evaluation of a Loran-C navigation system. The tests were performed in a Coast Guard HH-52A helicopter from 21 September to 19 October 1976. The flight test profiles, procedures and test objectives were developed to determine the applicability of the prototype Loran-C navigator to Coast Guard operations as well as to assess the functional and accuracy performance of the Loran-C navigator operating as an area navigation system in the National Airspace System. The operational testing reported in this document includes search and rescue missions as well as surveillance and enforcement missions. The former consisted of evaluating the Loran-C navigator during creeping line, sector, and expanding square search patterns. The latter involved performing low altitude hovers over fixed and movable objects and documenting Loran-C accuracy and repeatability. This latter data is also directly applicable to the operations of the off-shore oil industry. The functional and accuracy data testing performed is directly applicable to operations of Loran-C equipped aircraft in the National Airspace System (NAS). Enroute, terminal and approach data was taken near the Cape May, New Jersey region of the United States. Terminal area routes tested were chosen from the proposed area navigation routes developed for New York-Kennedy for the 1977 to 1982 time period. The NAS testing was performed at the National Aviation Facilities Experimental Center (NAFEC) in Atlantic City, New Jersey. The conclusions reached were: the navigator performed accurate, repeatable and operationally meaningful search and rescue missions with superior performance compared to current navigation techniques; the compatability of a Loran-C navigation system with both present and future planned area navigation routes and procedures was demonstrated; the accuracy was demonstrated to be within AC 90-45limits, and performance was satisfactory in off-shore operations.

MONROE ELECTRONICS INC. MODEL 225 K - PORTABLE ELECTROSTATIC FIELD METER

The outline and specifications below are from the equipment instruction manual.

The Model 225 Portable Electrostatic Fieldmeter measures electrostatic field (potential gradient) in volts/cm with respect to the (grounded) probe. (For portable operation, an alligator clamp lead is provided for connection to a suitable ground reference.) It may also be used to measure surface voltage by using the probe-to-surface separation as a calibration factor. The instrument is designed for either line or battery operation and comes equipped with a set of rechargeable nickel-cadmium batteries that will operate it continuously for 8 hours without recharging. It is ruggedly constructed for field use, and utilizes all solid state circuit components including modern integrated circuits for reliability.

Specifications: Range: -20,000 - 0 - +20,000 volts/cm. Zero center meter ranges of 200, 500, 1000, 2000, 5000, 10,000 and 20,000 volts/cm. A zero center logarithmic scale is also provided covering the entire range of the instrument on a single meter scale.

Sensitivity: **2 volts/cm

Static Accuracy: **Better than 5%

Drift: **Less than 5 volts/cm per hour, non-cumulative after 30 minute warm-up.

Noise: **Less than 2 volts/cm Rms

Speed of Response: Less than 50 msec., 10% to 90%

Output: An output connector is provided for external recording or control. Two output signals are available, linear, at -0.5 volt per Kv/cm, and logarithmic at -1 volt per decade.

ELECTRIC CHARGING OF HELICOPTERS ELEKTRISCHE AUFLADUNG VON HUBSCHRAUBERN

AUTHOR: Muehleisen, R., Fischer, H.J.
Tuebingen Univ. (Germany, F.R.).

1978 76p
Rept No: BMVG-FBWT-78-7

Abstract: In order to improve aircraft safety and reduce accidents, electrical measurements were made on UH 1D and CH 53 helicopters to determine charging in the atmospheric electric field, charging by exhaust gases, and charging from external forces such as precipitation and dust. The electric discharger mounted on the CH 53 helicopter is helpful only during fine weather, but not in the cases of high field strength. An improved method for discharging is recommended.

N79-18274/7ST

NAFEC FIVE-FOOT FIRE TEST FACILITY

The following is from NAFEC facility documentation and personal contact of facility personnel, June, 1979

The wind tunnel test section is 65 inches in diameter 16 foot in length. The test section has an access door 14 feet 8 inches long and 4 feet 6 inches wide. The interior of the test section is equiped with an acrylic observation window for viewing the article under test. The wind tunnel is capable of air speeds in the .85 mach (650-670 mph) range at altitude simulation of 13,000 to 15,000 feet.

MEASURING THE ELECTRICAL CHARGE AND VELOCITY OF A MOVING PROJECTILE

AUTHOR: Nanevicz, J.E., Wadsworth, W.C.
Stanford Research Inst Menlo Park Calif
Interim engineering rept. no. 1, jul 64-Jan 65
Jan 65 2p
Contract: AF33 615 1934
Project: 5082

Abstract: Two different probes were developed for measuring the electrical charge and velocity of a moving charged projectile. The probes were tested using 5/32-inchdiameter steel balls fired from a rifle at roughtly 4500 feet per second. The projectiles were frictionally charged to from 50 to 100 micromicrocoulomb by passing through a 0.0003-inch-thick plastic sheet. (Author)

AD-612 797

A STUDY OF INSTRUMENT ERRORS IN THE MEASUREMENT OF ELECTROSTATIC FIELDS AND THE DESIGN OF A NEW ELECTRIC FIELD METER

AUTHOR: Pilie, Roland J., Ford, James W.
Cornell Aeronautical Lab Inc Buffalo N.Y.
Feb 55 78p
Rept No: rm824 p 4
Contract: nonr90400

Abstract: No abstract available.

AD-082 564/6ST

PIPER'S ICE MACHINE

FROM: Business and Commercial Aviation (July 1979)

Basically, a Piper Cheyenne is equiped with water tanks and a spray ejection system. The system has a boom that is lowered from the aircraft during flight, out of the slip-stream, and a water and air mixture is ejected from the nozzles. The droplet size and density is controlled by the air/water mixture. Droplet size and density is measured by the test airplane on a microscope slide covered with geletin that is exposed to the air-ice stream for a fraction of a second. The slide is later examined on the ground for data. All ranges of icing conditions can be generated and the ice stream can be concentrated on any portion of the aircraft under test.

MINIMUM PERFORMANCE STANDARDS - AIRBORNE LORAN-A AND LORAN-C RECEIVING EQUIPMENT

RTCA Document No. DO-159 October 17, 1975

AIRCRAFT RESPONSE EFFECT ON E-FIELD MEASUREMENTS

AUTHOR: Schlegel, Gerard K.
R and D Associates Marina Del Rey Calif
Topical Rept.
EO474C4 Fld: 9E, 1C, 51E, 49A GRA17806
9 Mar 77 80p
Rept No: RDA-TR-140801-008
Contract: DNA001-77-C-0012
Project: P99QAXD
Task: B001
Monitor: AD-E300-042

Abstract: This report describes the effect of the aircraft response on the measurement of E-fields. In investigating this effect, the effective height data developed by the Boeing Corporation for a 1-m blade antenna on a C-130 aircraft was utilized. Difficulties in using this data are discussed, and calculated phase functions to correspond to the amplitude data are presented. Calculated antenna open circuit voltages are then presented for different free field variations and polarizations.

AD-A047 986/5ST

TECHNICAL ASSISTANCE FOR THE DEVELOPMENT AND EVALUATION OF AIRBORNE VLF NAVIGATION SYSTEMS

AUTHOR: unknown
Systems Control Inc., 260 Sheridan Ave., Palo Alto, Michigan 94306, United States of America
Sponsored by U.S. Dept. of Transportation, Federal Aviation Admin.,800 Independence Ave. S.W., Washington, District of Columbia, 20590, United States of America
Contract/Grant No.: FA75WA-3662; FA058654 (Trais No.)
10/77 to 9/78

Tasks include: 1) Preparation of Engineering Requirements 2) Development and Evaluation of Noise Cancellation Antenna System 3) Evaluation of 3.4 kHz Omega Airborne Receiver 4) Development and Evaluation of Civil Omega/VLF Airborne System 5) Development and Evaluation of Operation Type Diffential Omega System 6) Low Cost VLF Airborne Systems Evaluations 7) VLF Navigation System Study 8) Definitive Analysis of the Role of VLF Navigation in Aviation

APPARATUS FOR MEASURING THE RF NOISE PRODUCED BY PASSIVE STATIC DISCHARGERS FOR AIRCRAFT

AUTHOR: Tanner, Robert L.; Nanevicz, Joseph E.; Hilbers, George R.; Vance, Edward F.
Department of the Air Force
Patent
Filed 28 Jul 65, patented 4 June 68
Rept No: PAT-APPL-475 614
Monitor: 18

Abstract: *It is the purpose of this invention to provide a tester for measuring the RF* noise produced by static dischargers of which the above described types are examples. For measurements that will be directly related to the RF noise coupled into the aircraft antenna system when the discharger is installed on the aircraft, the tester must meet three basic requirements, namely: (1) the reciprocal field in the tester must conform to the reciprocal field at the discharger when installed on the aircraft, (2) the DC field inducing the corona discharge in the tester must conform to the DC field at the discharger when installed on the aircraft, and (3) the noise measured in the tester must be restricted to the response frequency range of the receiver.

PATENT-3 387 215

LOW FREQUENCY ELECTRIC FIELD CHARACTERISTICS OF CLEAR AIR TURBULENCE

AUTHOR: TenBroek, H.W.; Seashore, C.R.
Honeywell Inc St Paul Minn Research Dept (401799)
Final rept. 15 Mar 66-15 Jul 67
15 Jul 67 157p
Rept No: 12037-FR1
Contract: AF 19(628)-5983
Project: AF-6020
Task: 62003
Monitor: AFCRL-67-0457

Abstract: The report covers work done to investigate the low-frequency electric field characteristics of clear air turbulence. A description is given of the electric field sensing system designed and constructed by Honeywell and installed in five Northwest Airlines 720B passenger jets. The equipment was used to gather experimental data on the correlation of electric field activity with CAT, when encountered, during the scheduled flights of these aircraft in the period between October 1966 and June 1967 (a total flight time for all five CAT units of approximately 4300 hours). In this period, a total of 2,320 hours of recorded electric field data was obtained, during which 131 pilot-indicated encounters with CAT occurred. An investigation of the correlation of these encounters with the recorded data is presented, and the effects of various noise sources on system operation are discussed. The results of the data-taking program indicates that significant electrical activity occurred prior to and during 51.5 percent of those pilot-indicated CAT encounters exhibiting g-activity greater than plus or minus .05 g. Meteorological analyses of weather conditions in the vicinity of the encounters, useful in differentiating between the types of CAT encountered and in substantiating pilot-indicated events, could not be performed within the scope of the program.

AD-658 875

TASK I REPORT ON LORAN-C RFI AND NOISE

AUTHOR: Vincent, W.R. and Sage, G.
Los Angeles, California
Prepared for: Gould Inc. Fort Worth, Texas
RN. 6893/6894-0179

E. Loran-C Literature Sample.

F1382J2 N79-21035/7ST
Results of the Second Flight Test of the LORAN-C Receiver/Data Collection System
Fischer, J.P.
Ohio Univ., Athens. Avionics Engineering Center.
Mar 79 9p
Rept No: NASA-CR-158381: TM-68

F1382J1 N79-21034/0ST
Loran-C Flight Data Base
Lilley, R.W.
Ohio Univ., Athens. Avionics Engineering Center.
Feb 79 12p
Rept No: NASA-CR-158380: TM-67

F1381D3 NTIX/PS-79/0524/3ST
Loran C Navigation (Citations for the Engineering Index Data Base); Rept. for 1970-May 79
Reed, William E.
National Technical Information Service, Springfield, VA.
Jun 79 130p
Supersedes NTIS/PS-78/0532 and NTIS/PS-77/0337. For the companion Published Search of the NTIS Data Base, see NTIS/PS-79/0523.

F1381D2 NTIS/PS-79/0523/5ST
Loran C Navigation (Citations from the NTIS Data Base); Rept. for 1964-May 79
Reed, William E.
National Technical Information Service, Springfield, VA.
Jun 79 152p
Supersedes NTIS/PS-78/0531 and NTIS/PS-77/0336. For the companion Published Search of the Engineering Index Data Base. see NTIS/PS-79/0524

F0513K1 N79-13019/1ST
Loran-C Time Difference Calculations
Fischer, J.P.
Ohio Univ., Athens. Avionics Engineering Center.
Oct 78 10p
Rept No: NASA-CR-157957; TM-63

F0513J4 N79-13018/3ST
Initial Flight Test of a LORAN-C Receiver/Data Collection System
Fisher, J.P.; Nickum, J.D.
Ohio Univ., Athens. Avionics Engineering Center
Nov 78 46p
Rept No: NASA-CR-157629; TM-64

E2765H4 N78-31069/5ST
Loran-C Flight Test Software
Nickum, J.D.
Ohio Univ., Athens. Dept. of Electrical Engineering.
Aug 78 25p
Rept No: NASA-CR-157581; TM-61

E2765H3 N78-31068/7ST
Phase-Locked Tracking Loops for LORAN-C
Burhans, R.W.
Ohio Univ., Athens. Dept. of Electrical Engineering.
Aug 78 25p
Rept No: NASA-CR-157582; TM-60

E2765H2 N78-31067/9ST
Computing LORAN Time Differences with an HP-25 Hand Calculator
Jones, E.D.
Ohio Univ., Athens. Dept. of Electrical Engineering
Aug 78 11p
Rept No: NASA-CR-157580; TM-59

E1695L2 AD-A054 474/2ST
Economic Analysis of Future Civil Air Navigation Systems; Final rept. for CY 1977.
Joglekar, Anil N. ; Seiler, Karl III
Mitre Corp Mclean Va Metrek Div
Dec 77 35p

E1612H3 NTIS/PS-78/0532/8ST
Loran C. Navigation (Citations from the Engineering Index Data Base); Final rept. for 1970-Mar 78
Reed, William E.
National Technical Information Service, Springfield, Va.
Jun 78 116p
Supersedes NTIS/PS-77/0337. See also NTIS/PS-78/0531

E1612H2 NTIS/PS-78/0531/0ST
Loran C Navigation (Citations for the NTIS Data Base)
Final rept. for 1964-Mar 78
Reed, William E.
National Technical Information Service, Springfield, Va.
May 78 130p
Supersedes NTIS/PS-77/0336. See also NTIS/PS-78/0532.

E1475J4 N78-20100/1ST
Stand-Alone Development System Using a KIM-1 Microcomputer Module
Nickum, J.D.
Ohio Univ., Athens. Avionics Engineering Center.
Mar 78 13p
Rept No: NASA-CR-156067; NASA-TM-56

E1333K2 AD-902 360/7ST
LORAN/OMEGA Receiver Study; Final rept. 1 Jul 71-30 Apr 72
Chen, Paul; Culver, Calvin; Daniel, Donald B.; Danklefs, Ron
Teledyne Systems CO Northridge Calif
30 Jun 72 488p
Rept No: TSC-1119
Distribution limitation now removed.

E1104E2 N78-17032/1ST
Loran-C Digital Word Generator for Use with a KIM-1 Microprocessor System
Nickum, J.D.
Ohio Univ., Athens. Dept. Of Electrical Engineering.
Dec 77 14p
Rept No: NASA-CR-155304; TM-54

E01824K4 N77-32399/6ST
Circuit Methods for VLF Antenna Couplers
Burhans, R.W.
Ohio Univ., Athens. Avionics Engineering Center.
Sep 77 13p
Rept No: NASA-CR-155036; TM-53

D3821A2 N77-30101/8ST
Interactive LORAN-C to Geographic and Geographic-to- LORAN-C Computation
Piecuch, L.M.; Lilley, R.W.
Ohio Univ., Athens. Dept. Of Electrical Engineering.
Aug 77 6p
Rept No: NASA-CR-153985; TM-52

D2845C1 AS-A040 320/4ST
Experimental Research on the Propagation of Loran-C Signals.
Volume D. Data And Analysis; Technical memo.
Fehlner, L.F.; Jerardi, T.W.; McCarty, T.A.; Roll, R.G.;
Smith, R.R.
Johns Hopkins Univ Laurel Md Applied Physics Lab
Jan77 390p
Rept No: APL/JHU-TG-1298D
Availability: Microfiche copies only.
See also Volume A, AD-A034 193.

D2574C2 AD-A039 498/1ST
An Operational Flight Test Evaluation of a Loran-C Navigator; Final Report
Hughes, M., Adams, R. J.
Systems Control Inc Palo Alto Calif
Mar 77 128p

D2511C3 NTIS/PS-77/0337/4ST
Loran C Navigation (Citation from the NTIS Data Base); Rept. for 1970-Mar 77
Reed, William E.
National Technical Information Service, Sprinfield, Va.
May 77 94p
See also NTIS/PS-77/0336.

D2511C2 NTIS/PS-77/0336/6ST
Loran C Navigation (Citation from the NTIS Data Base); Rept for 1964-Mar 77
Reed, William E.
National Technical Information Service, Springfield, Va.
May 77 112p
See also NTIS/PS-77/0337

D2174L2 AD-801 187/6ST
Timing Subsystem Analysis. An Investigation of the Problem of Time Coincidence and Methods for Precise Synchronization of Widely Separated Clocks
Lockheed Missiles and Space CO Sunnyvale Calif
20 Aug 62 56p
Rept No: LMSC-A082391
Distribution limitation now removed

D1963B3 N77-14166/1ST
The Most Important Subsystems of the Helios Command Station at Weilheim-Lichtenau
Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. fuer Flugfunk und Mikrowellen.
Apr 76 151p
Rept No: BMFT-FB-W-76-04
In German; English Summary
Conf-Proc. Of a Tech.-Sci. Colloq. Held at Weilheim-Lichtenau, West Ger., 20Mar. 1975.

D1825L3 N77-13927/7ST
Greenwich Time Report, October-December 1975
Royal Greenwich Observatory, Herstmonceux (England). Time and Latitude Service.
Dec 75 17p

D181414 N77-13037/5ST
NASA Tracking Ship Navigation Systems
Mckenna, J.J.
National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md.
Aug 76 31p
Rept No: NASA-TM-X-71228; X-814-76-190
Cont-presented at the Precise Time and Time Interval Meeting
(Ptti), Dec. 1975.

D136514 N77-10976/7ST
Greenwich Time Report, July - September 1975
Royal Greenwich Observatory, Herstmonceux (England). Time and Latitude Service.
Sep 75 17p

D1304C4 AD-A034 193/3ST
Experimental Research on the Propagation of Loran-C Signals. Volume A. Summary Report; Technical memo.
Fehlner, L.F., Jerardi, T.W., McCarty, T.A., Roll,R.G.
Johns Hopkins Univ Laurel Md Applied Physics Lab
Oct 76 77p
Rept No: APL/JHU-TG-1298A
See also report dated Aug 76, AD-A029 888

D1244J1 PB-260 675/4ST
LORAN-C Feasibility Demonstration Plan; Final rept. Jul 75-Aug 76
New York State Dept. Of Motor Vehicles, Albany, **Polhemus Navigation Sciences, Inc., Burlington, Vt. *National Highway Traffic Safety Administration, Washington, D.C.
Oct 76 45p
Prepared in cooperation with Polhemus Navigation Sciences, Inc., Burlington, Vt.

D1114D1 AD-A032 811/2ST
Evaluation of High Power Tubes for Loran-C Use; Interim rept. no. 1, May 75-Sep 76
Sobotka, Gary R.
Coast Guard Wildwood N J Electronics Engineering Center
11 Nov 76 37p
Rept No: EECEN-WX016-B4

D110213 AD-A032 497/0ST
An Overview of Enroute Radio Navigation Services for Civil Aviation ; Final rept.
Yulo, Carlo
Federal Aviation Administration Washington D.C. Systems Research and Development Service
Aug 76 21p
Rept No: FAA-RD-76-187

D0234K4 N76-31499/6ST
Greenwich Time Report, April-June 1975
Royal Greenwich Observatory, Herstmonceux (England). Time and Latitude Service.
Jun 75 17

D0065L1 PB-258 251/8ST
LORAN-C Conceptual Analysis; Final rept. Jul 75-Jun 76.
New York State Dept. of Motor Vehicles, Albany. *Polhemus Navigation Sciences, Inc., Burlington, Vt. *National Highway Traffic Safety Administration, Washington, D.C.
Jul 76 89p
Prepared in cooperation with Polhemus Navigation Sciences, Inc., Burlington, Vt.

C7612C1 AD-A030 337/0ST
A Comparison of Air Radionavigation Systems (For Helicopters in Off-Shore Areas); Final rept.
Quinn, George H.
Federal Aviation Administration Washington D.C. Systems Research and Development Service
Aug 76 20p
Rept No: FAA-RD-76-146

C7512G1 AD-A029 888/5ST
Experimental Research on the Propagation of Loran-C Signals. Volume B. Test Operations; Technical memo.
McCarty, T.A., Oden, S.F., DeLorica, C.M., Smith, R.R., Klepczynski, W.J.
Johns Hopkins Univ Laurel Md Applied Physics Lab
Aug 76 92p
Rept No: APL/JHU-TG-1298B

C7342H3 AD-908 193/6ST
Optimum Reset of Ship's Inertial Navigation System
Bona, B.E., Smay, R.J.
Autonetics Anaheim Calif
1965 21p
Rept No: X4-1981/3111
Distribution limitation now removed

C7342C2 AD-907 896/5ST
Propagation Delay Time for HF Signals; Technical rept. no. 40
Ernst, Edward W.
Illinois Univ Urbana Radiolocation Research Lab
Jan 73 139p
Rept No: RRL-Pub-423; UILU-ENG-73-2538
Distribution limitation now removed

C7315B1 AD-896 039/5ST
'Locate' System and AN/ARN-94 Loran-C Receivers Test and Evaluation; Final Rept.
Shillito, Gordon
Coast Guard Wildwood N.J. Electronics Engineering Center
5Aug 71 19p
Distibution limitation now removed

C7311F1 AD-893 468/9ST
Preliminary Results on the Performance of the AN/PSN-4(XE-1) (V)2 and Coordinate Converter at Fort Benning, Georgia; Technical rept.
Anderson, C.W. III
Army Electronics Command Fort Monmouth N.J.
Mar 72 15p
Rept No: ECOM-3438
Distribution limitation now removed

C7271G3 AD-881 014/5ST
Proceedings from Precise Time and Time Interval (PTTI) Strategic Planning Meeting, December 10-11, 1970. Volume I
Naval Observatory Washington D.C.
Dec 70 187p
Distribution limitation now removed
See also Volume 2, AD-514 056L.

C6753H3 N76-20034/4ST
Greenwich Time Report, October-December 1974
Royal Greenwich Observatory, Herstmonceux (England). Time and Latitude Service.
Dec 74 16p

C6445F1 AD-A023 478/1ST
Analysis of the Potential Application of Space Telecommunications Systems to U.S. Coast Guard Missions; Final rept. Jun 73-Nov 74
Mueller, Edward J., Kuegler, George K., Willman, Carl E.
Westinghouse Electric Corp Baltimore Md Aerospace and Electronic Systems Div
Nov 74 520p
Rept No: 75-0018

C6131G2 N76-13984/9ST
Greenwich Time Report, July - September 1974
Royal Greenwich Observatory, Herstmonceux (England). Time and Latitude Service.
Sep 74 20p

C5561C1 N75-31197/7ST
An Analysis of Spacecraft Data Time Tagging Errors
Fang, A.C.
National Aeronaurtics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.
Sep 75 34p
Rept No: NASA-TN-D-8073; G-7607

C5072B4 AD-A013 211/8ST
Oceanology's Charting and Navigation Facility; Final rept.
Zuccaro, Anthony; Ostrander, John H.
Naval Research Lab Washington D.C.
13 Jul 75 77p
Rept No: NRL-7875

C4212K4 AD/A-004 777/9ST
Calibration of Relative Position Errors of the Range Capable Data Link and Loran-C; Technical rept.
Westbrook, E.A.
Mitre Corp Bedford Mass
Jan 75 35p
Rept No: MTR-2798
Electronic Systems Div., Hanscom AFB, Mass

C4133D1 AD/A-003 800/0ST
Oceanic Air Route Navigation with Envelope Match Loran-C; Final rept.
Reynolds, Patrick R.J.
Pan American World Airways Inc. Jamaica N.Y. *Federal Aviation Administration, Washington, D.C.
Dec 74 127p

C411214 N75-10905/8ST
On Time Scales and Time Synchronization Using Loran-C as a Time Reference Signal
Chi, A.R.
National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md.
Sep 74 55p
Rept No: NASA-TM-X-70774; X-810-74-284
Conf-presented at the NASA-DOD Ptti Meeting, Naval Research Lab, 3-5 Dec. 1974

C3944D1 N74-34153/8SL
A Comparative Analysis of Area Navigation Systems in General Aviation; M.S. Thesis
Dodge, S.M.
Massachusetts Inst. Of Tech., Cambridge. Flight Transportation Lab
Jun 73 190p
Rept No: NASA-CR-132504; FTL-R74-1

C2755A3 AD-777 500/0
An Analysis of Loran and Wind-Measuring Accuracies for Application to Field Army Use; Research and Development technical rept.
Barr, William C.
Army Electronics Command Fort Monmouth N.J.
Apr 74 47p
Rept No: ECOM-5536

C2524G1 AD-775 438/5
Computer Evaluation of Loran-C Antennas; Final rept.
Miller, Edmund K., Deadrick, Fred J.
California Univ Livermore Lawrence Livermore Lab
17 Oct 73 131p
Rept No: UCRL-51464

C0751L1 AD-758 739
Proceedings of the Annual Department of Defense Precise Time and Time Interval (PTTI) Strategic Planning Meeting (3rd) Held at Washington, D.C. on 16-18 Nov 1971
Naval Observatory Washington D.C.
1973 430p
See also Volume 1, AD-881 014

C0603D4 AD-757 142
Coastline Induced Loran-C Anomalies; Technical rept.
Anderson, Chester W. III, Pearce, Douglas C., Walker, John W.
Army Electronics Command Fort Monmouth N.J.
Feb 73 20p
Rept No: ECOM-4075

A5532G3 N72-29832
Report on the Lunar Ranging at McDonald Observatory; Technical Report, 16 Feb. 1972 - 15 May 1972
Silverberg, E.C.; Wiant, J.R.
Texas Univ., Austin
May 72, 37p
Rept No: NASA-CR-127788; RM-72-007

A4675E4 N72-22862
Greenwich Time Report, January - March 1971
Royal Greenwich Observatory, Herstmonceux (England)
Mar 71 24p

A4285K3 AD-740 894
Precision Aircraft Navigation Based on Loran-C and Digital Altimetry; Technical memo
Fehlner, L.F.
Johns Hopkins Univ Silver Spring Md Applied Physics Lab
Jan 72 73p
Rept No: APL-TG-1184

A4185A1 AD-740 299
Cross-Rate Interference Study; Final engineering rept. 24Jun-24 Oct 63
ITT Federal Labs Nutley N.J.
Nov 63 88p
Rept No: ITTFL-TD-63-313
Available in microfiche only.

A4155G3 N72-16245
Information Relative to Cartography and Geodesy. Series 2 German Contibutions in Foreign Languages, No. 26
Institut Guer Angewandte Geodaesie, Frankfurt Am Main (West Germany).
1970 24p

A4004L3 AD-881 014
Proceedings from Precise Time and Time Interval (PTTI0 Strategic Planning Meeting (2nd) Held at Washington, D.C., on 10-11 December 1970. Volume 1
Naval Observatory, Washington, D.C.
1 Jan 71 187p
Distribution Limitation now Removed

A2533D3 N71-24880
Operational Considerations for the Use of LORAN-C Skywaves for Time Synchronization
Mazur, W.E. Jr
National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md.
Apr 71 52p
Rept No: NASA-TM-X-65515, X-573-71-148

A1301A1 AD-715 255
Pulse-Phased Radio Navigation System Loran-C
Bykov, V.I., Nikitenko, Yu. I.
Naval Intelligence Command Alexandria Va Translation Div
24 Nov 70 93p
Rept No: NIC-Trans-3139
Trans. of mono. Impulsno-Fazovaya Radionaviatsionnaya Sistema Loran-C, Moscow, 1967 p2-95

A0861H1 N70-32463
Hydrogen-Maser Time and Frequency Standard at Agassiz Observatory
Levine, M.W., Vessot, R.F.
Smithsonian Astophysical Observatory, Cambridge, Mass.
Apr 70 19p
Rept No: NASA-CR-110689; REPT-004-20
Conf- Presented At the Symp. on Very Long-baseline Interferometry, Charlottesville, Va., 13-15 Apr. 1970

A049111 N70-26328
Greenwich Time Report, April - June 1969
Woolley, R.V.
Royal Greenwich Observatory, Herstmonceux (England). Time and Latitude Service.
1969 14p

A0341B1 N70-23803
Flight Test of Operation of Loran-C; Flugerprobung des Betriebsverhaltens Von Loran C
Blanchard, W.
Decca Navigator Co., Ltd., London (England)
1969 21p
Ortung Und Navigation Date; 1969 Coll- 21 P Refs Lang- in German Conf- Presented At the Inter. Navigation Meeting, Hamburg, 28-30 Oct. 1969

4173A3 N68-11468
Time Synchronization of Remote Station Clocks
Stetina, F.L.
National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md.
Mar 67 14p
Rept No: NASA-TM-X-63036; X-553-67-130

73030523 v1n5
VLF radio Navigation
Wilson, J.E.
Airborne Navigation Corp.
National Business Aircraft Meeting A732172 Wichita, Kansas 3-6 Apr 73
Society of Automotive Engineers
Preprints, 7 Apr 73; members $1.25 each, others $2.00 each (order by number, prepayment required): Society of Automotive Engineers, Dept. 251, Two Pennsylvania Plaza, New York, N.Y. 10001.)

APPENDIX B. OHIO UNIVERSITY DC-3 P-STATIC INSTALLATIONS DETAILS

The installations for measurement of p-static effects of airframe charging/discharging phenomena on Loran-C consist of two separate systems. The first is a set of airframe dischargers mounted on insulated bases and wired for measurement of discharge current using meter or chart-recorder output. The second is a set of two electric-field probes for measuring the electrostatic field in the aircraft vicinity.

The DC-3, of course, provides space for additional mission-dependent instrumentation. See Appendix C for one such installation of a noise-level receiver.

A. Instrumented Airframe Dischargers. Figure B-1 shows the circuitry and wiring added to DC-3 N7AP for measurement of discharge current from any or all of the twelve dischargers installed. The discharger selector switches are installed in pictorial positions relating to discharger positions on the aircraft, for convenient operation.

The meter reads microamperes directly; chart record output is 1 mv/μA.

B. Electrostatic Field Meter and Probes. To measure the electric field in the vicinity of the aircraft, and to detect the presence of crossed-field effects in flight, two electrostatic field meter probes are installed on the aircraft surface. A commutating switch connects either probe to the field meter, or causes periodic switching from the top-mounted probe to the bottom-mounted unit at a selectable rate. The field meter provides direct meter display of the field, and the meter output can be chart-recorded during flight.

1. Field Meter. The Monroe 225K field meter is installed, with two Model 1007 vibrating-capacitor probes with protective covers. The meter is capable of field measurement from $\pm$ 20 v/cm to $\pm$ 20,000 v/cm. Figure B-2 gives field meter specifications.

2. Field Probe Commutator. To allow one field meter unit to receive data from two probes, reducing cost and complexity of the installation, the field probe commutator unit shown in Figure B-3 has been installed. This commutator uses a 555 IC timer to generate the switching waveform, which is then divided by two in the 74LS74D flip-flop. The flip-flop output is then used to switch the coil drive relay and the analog switch chips. Probe output lines are switched using Analog Devices AD7512D1 chips, while the AC probe vibrator coil voltage is commutated using the relay.

The result of commutator use is a slowly-sampled waveform on the chart recorder, giving alternately the output of the top-mounted probe and then the bottom-mounted field probe. The Switching Disable control on the commutator permits use of either field probe without commutation, by stopping the switcher with the appropriate probe connected. A front-panel light indicates which probe is connected.

Figure B-4 gives details of the Analog Devices switch chips, for documentation.

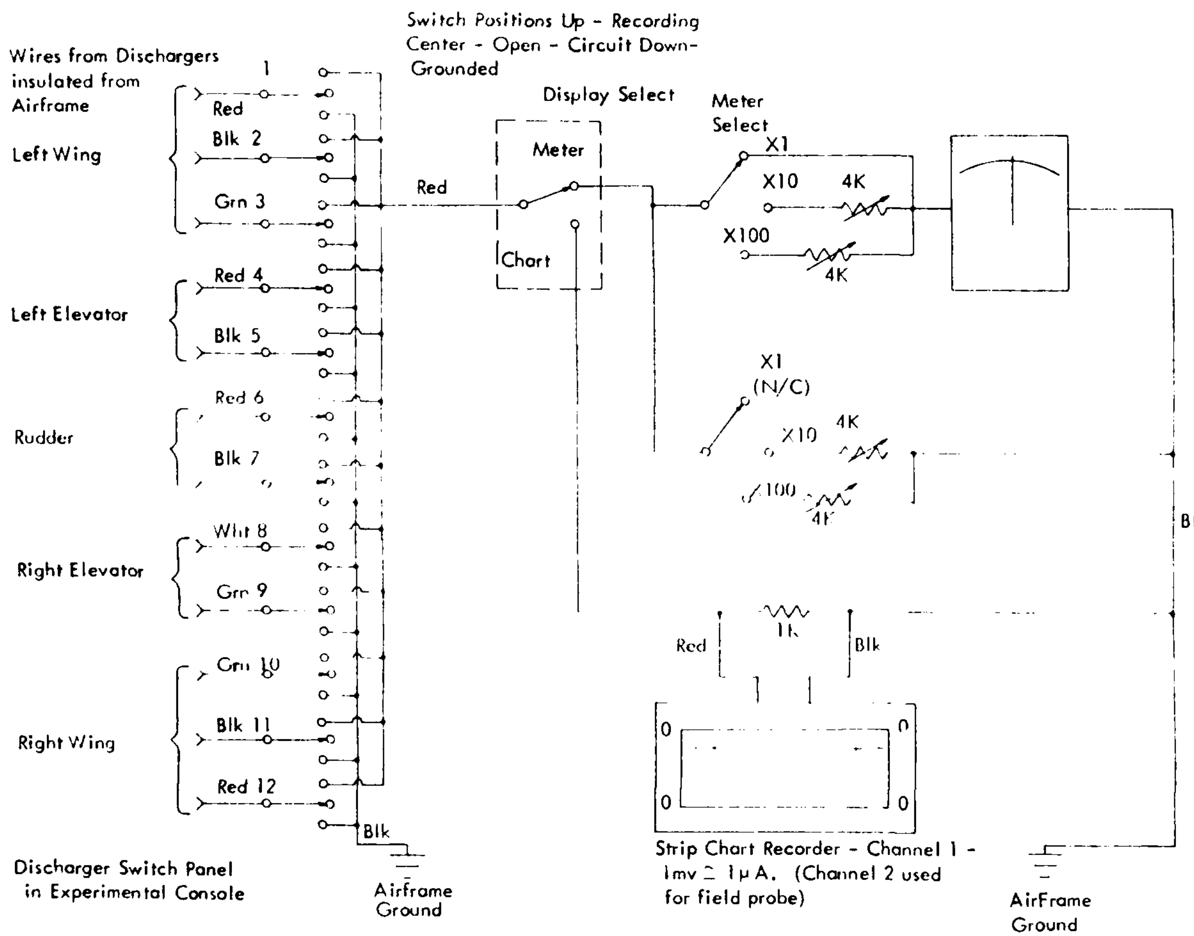


Figure B-1. Airframe Discharger Instrumentation.

Monroe 225 K Field Meter

Specifications:

Range: -20,000 - 0 - +20,000 volts/cm. Zero center meter ranges of 200, 500, 1000, 2000, 5000, 10,000 and 20,000 volts/cm. A zero center logarithmic scale is also provided covering the entire range of the instrument on a single meter scale.

Sensitivity: **2 volts/cm.

Static Accuracy: **Better than 5%.

Drift: **Less than 5 volts/cm per hour, non-cumulative after 30 minute warm-up.

Noise: **Less than 2 volts/cm Rms.

Speed of Response: Less than 50 msec., 10% to 90%.

Safety: A maximum of 15 volts and 10^{6} Joule is available at the probe to minimize spark hazards and provide for personnel safety.

Power Requirements: 177 volts AC, ± 10%, 50/60 Hz, 7 watts.

Battery Life: 8 hours of continuous operation without recharing. Rechargeable a minimum of 1000 times (with normal care as required by Nickel-Cadmium type batteries).

Probe Dimensions: 1007 type. 2-3/16" x 2-3/16" x 1-7/8" high. Four 4-40 machine screws on 1" centers, two tapped in. each side of the probe are provided for mounting.

Output: An output connector is provided for external recording or control. Two output signals are available, linear, at -0.5 volt per Kv/cm., and logarithmic at -1 volt per decade.

Size and Weight: 6" x 9" x 8½" high case (with carrying handle and strap). 10 lbs.

** These parameters are specified in an uncontaminated atmosphere at constant temperature and humidity.

Figure B-2. Field Meter Specifications.

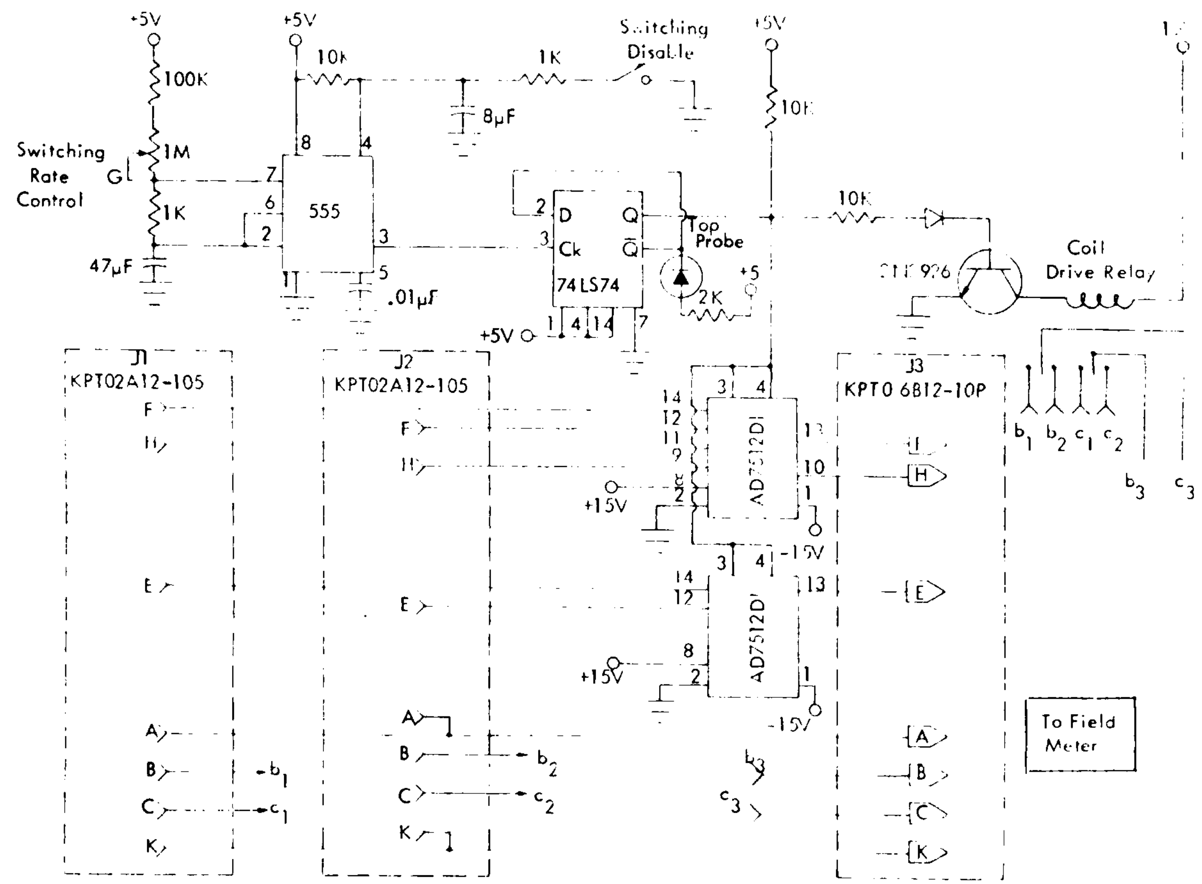


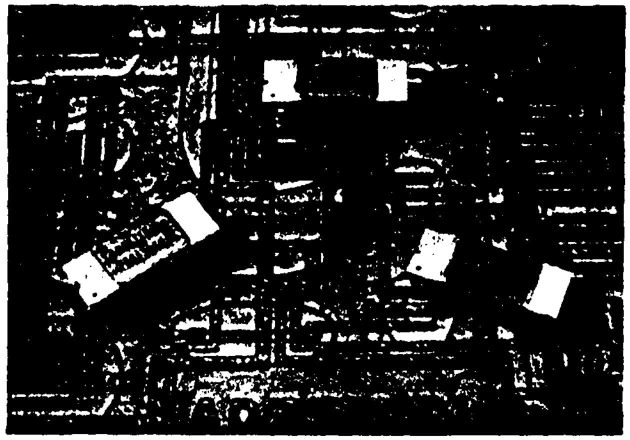
Figure B-3. Electrostatic Field Meter Commutation Circuitry.

ANALOG DEVICES

DI CMOS Protected Analog Switches

AD7510DI, AD7511DI, AD7512DI

FEATURES
Latch-Proof
Overvoltage-Proof: ±25V
Low R_{ON}: 75Ω
Low Dissipation: 3mW
TTL/CMOS Direct Interface
Silicon-Nitride Passivated
Monolithic Dielectrically-Isolated CMOS



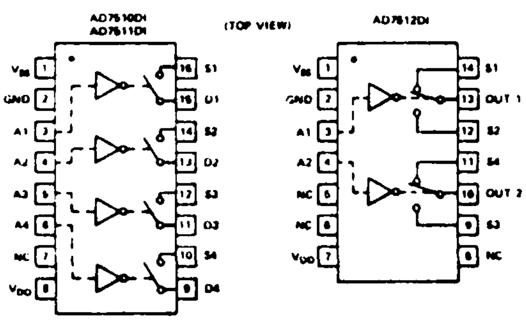
GENERAL DESCRIPTION

The AD7510DI, AD7511DI and AD7512DI are a family of latch proof dielectrically isolated CMOS switches featuring overvoltage protection up to ±25V above the power supplies. These benefits are obtained without sacrificing the low "ON" resistance (75Ω) or low leakage current (400pA), the main features of an analog switch.

The AD7510DI and AD7511DI consist of four independent SPST analog switches packaged in a 16-pin DIP. They differ only in that the digital control logic is inverted. The AD7512DI has two independent SPDT switches packaged in a 14-pin DIP.

Very low power dissipation, overvoltage protection and TTL/CMOS direct interfacing are achieved by combining a unique circuit design and a dielectrically isolated CMOS process. Silicon nitride passivation ensures long term stability while monolithic construction provides reliability.

PIN CONFIGURATIONS



ORDERING INFORMATION

Plastic (Suffix N)	Ceramic (Suffix D)	Operating Temperature Range
AD7510DIJN		0 to +70°C
AD7510DIKN		
AD7511DIJN		
AD7511DIKN		
AD7512DIJN		
AD7512DIKN		
	AD7510DIJD	-25°C to +85°C
	AD7510DIKD	
	AD7511DIJD	
	AD7511DIKD	
	AD7512DIJD	
	AD7512DIKD	
	AD7510DISD	-55°C to +125°C
	AD7511DISD	
	AD7511DITD	
	AD7512DISD	
	AD7512DITD	

CONTROL LOGIC

AD7510DI: Switch "ON" for Address "HIGH"

AD7511DI: Switch "ON" for Address "LOW"

AD7512DI: Address "HIGH" makes S1 to Out 1 and S3 to Out 2

Route 1 Industrial Park; P.O. Box 280; Norwood, Mass. 02062
Tel: 617/329-4700 TWX: 710/394-6577
West Coast 714/842-1717 Mid-West 312/894-3300 Texas 214/231-5094

Figure B-4. Analog Switch Data.

APPENDIX C. PRELIMINARY FLIGHTS FOR INSTALLATION CHECKOUT

Two cross-country flights were made with the p-static instrumentation on board DC-3 N7AP. These flights were for the purpose of initial system checkout and problem identification. At the conclusion of both flights, system changes were accomplished which placed the sensor and data-recording systems in operating condition for p-static measurement.

Completion of instrumentation will include a Loran-C receiver with a choise of antenna types and a biased-discharger for simulating p-static events in clear air.

It has also been observed that the DC-3 aircraft, an older airframe with long years of use, will require a corona survey and corrective action for discharge points resulting from skin and antenna bonding imperfections. The aircraft is equipped with a non-metallic radome nose, which will require discharge paths for streamer current dischargers.

A. Flight Evaluation: Boston, Massachusetts, Area, September 11, 1980.

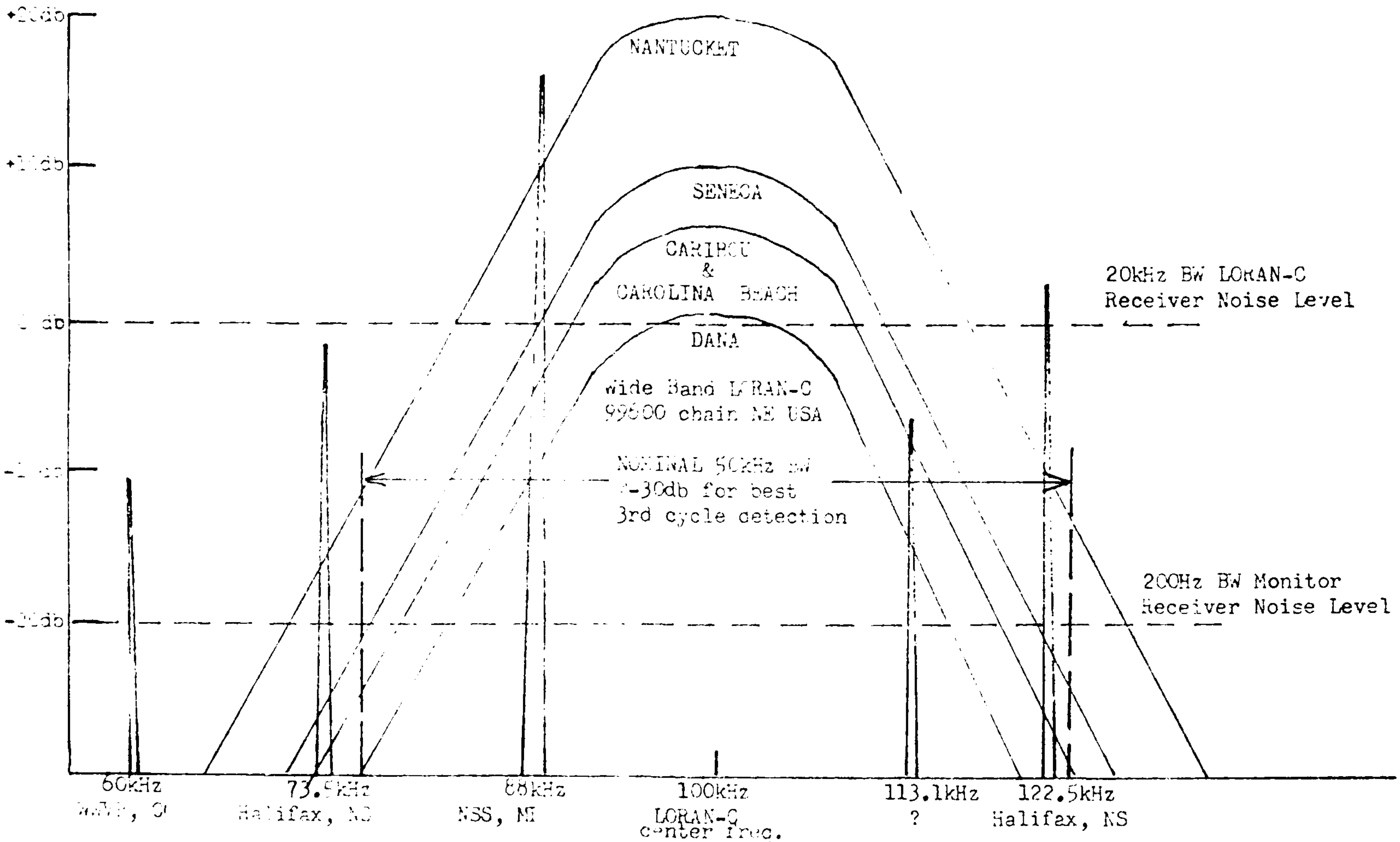
1. Interference Spectrum Measurements. Figure C-1 shows baseline data for Loran-C signal-to-noise ratios in the presence of coherent, identifiable, interference sources. P-static was not a factor on this particular test, as weather conditions were essentially clear, and the flight was conducted at low altitudes free of clouds. The graph shows, however, the capabilities installed in the DC-3 aircraft for noise spectrum measurements. This equipment will remain available for Loran-C p-static testing utilizing the DC-3. Instrumentation consists of a long-wire antenna, top-mounted on the aircraft, and a low-frequency receiver designed and fabricated at Ohio University.

The receiver used to obtain an estimate of interference levels encountered during Loran-C test flights is illustrated in block diagram form with a front panel photograph in Figure C-2. The receiver has been briefly described at the NASA Tri-University Quarterly Review Meeting held at Princeton, New Jersey, April 11, 1980. A general discussion of direct conversion receivers as applied to VLF signal reception is found in LOWDOWN*.

This receiver is manually tuned and has a narrow bandwidth audio filter for observing the beat note as the local oscillator is tuned across the signal frequency. The amplitude of the beat note is approximately proportional to signal level, which can be measured over a very wide range, by varying the LO injection level and observing the level indicator calibration. The injection level is calibrated with known signal input levels from the antenna preamp to obtain signal amplitudes during a flight test. The very high noise levels in the DC-3 aircraft and the general problems of tuning and adjusting a receiver of this type permit only an estimate of the signal levels observed.

B. Flight Evaluation: Athens, Ohio, to Cleveland, Ohio, and Return, September 31, 1980. The flight was made in partly-cloudy weather; instrumented dischargers and field meter were installed and operated throughout the enroute portions of the flight. The flight allowed identification of two problems in instrumentation:

* LOWDOWN is a monthly newsletter published by the Longwave Club of America, LWCA, P.O. Box 33188, Granada Hills, California, 91344 (Volume 7, No. 8, pp. 8-11, August 1980).



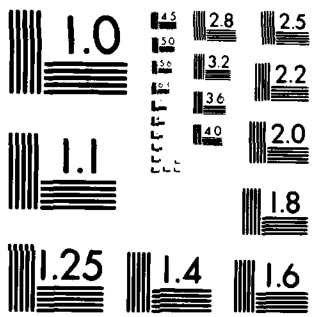
ESTIMATED SIGNAL & NOISE LEVELS LORAN-C
Flight Test, Hanscom Field, Mass. Sept 11, 1980

Figure C-1. Baseline Data for Loran-C Signal-to-Noise Ratios in the Presence of Coherent, Identifiable, Interference Sources.

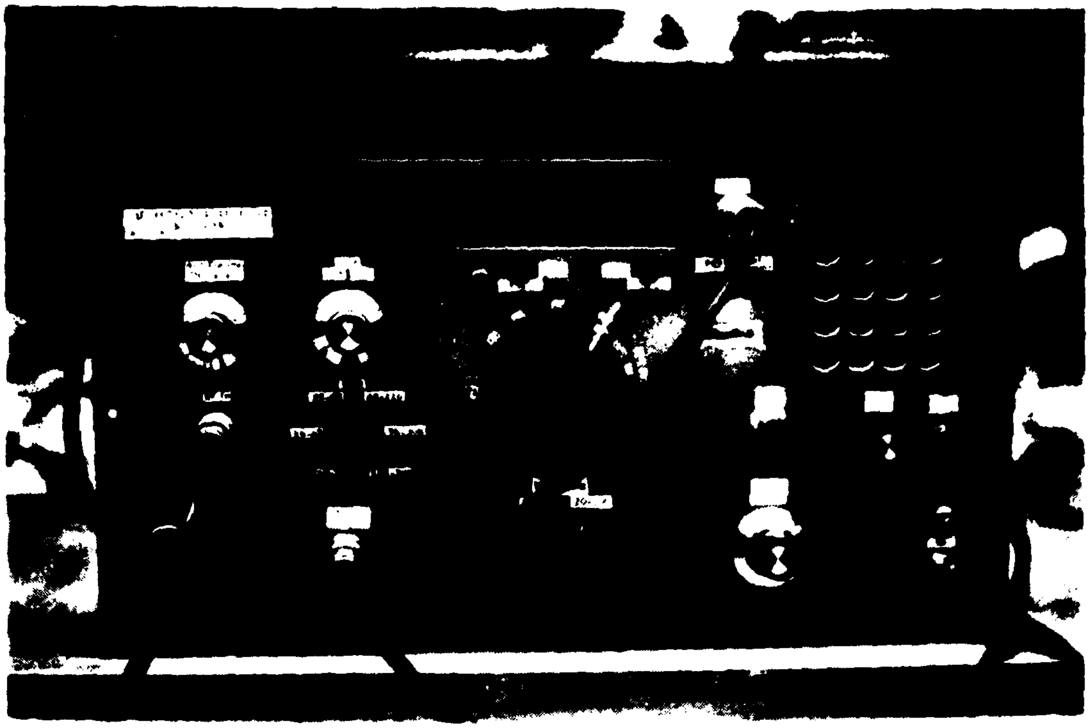
AD-A098 451 OHIO UNIV ATHENS DEPT OF ELECTRICAL ENGINEERING F/G 17/7
VLF P-STATIC NOISE REDUCTION IN AIRCRAFT. VOLUME I. CURRENT KNO--ETC(U)
SEP 80 R W LILLEY, R W BURHANS DOT-FA79WA-4320
UNCLASSIFIED EER-48-1 FAA-RD-80-137-1 NL

2/2

END
DATE
FILMED
5 81
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A



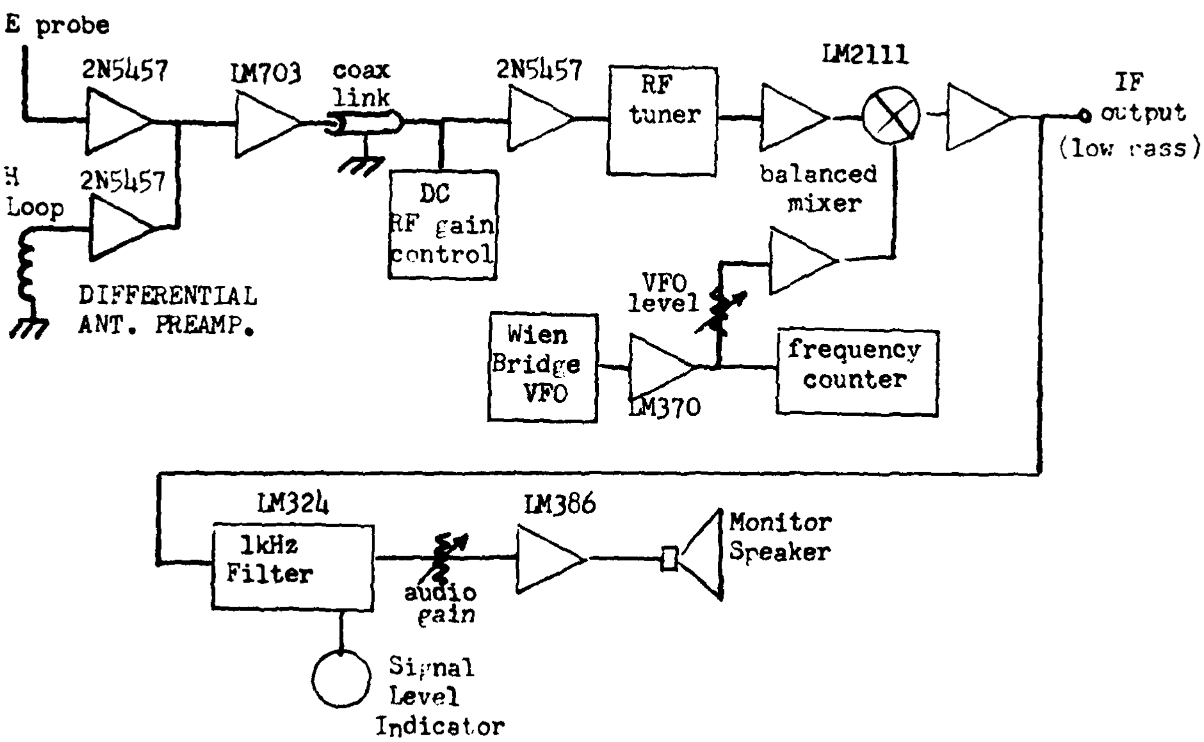


Figure C-2. Experimental Direct Conversion VLF Receiver.

(1) the circuitry including the microammeter and chart recorder interface must be altered to prevent self-generated voltage due to turbulence effects on the meter from affecting the chart-recorder trace and (2) the electrostatic fieldmeter should be operated using the aircraft internal 110 VAC supply rather than internal battery supply. These problems were corrected after the flight.

Figure C-3 documents the data-collection form used in conjunction with the discharger/fieldmeter chart recordings to capture p-static data. The flight to Cleveland permitted an exercise of this data-collection process, even though significant p-static events were not observed.

TIME	DISCHARGERS (V=ON) 1	2	3	4	5	6	7	8	9	10	11	12	I (from meter) (μA)	AIR SPEED (knots)	ALTITUDE (feet)	HEADING	FREE AIR TEMP (C°)	EVENT MARK	9/12/80 WEATHER
1700														TAKEOFF			15		Light Haze - alto stratus
1730	X	X	X											125	7000	275	10		Light clouds below
1830										X	X	X		140	8000	275	9		Hazy
1851														140	8000	250	9		Clear
1924	X	X	X					X	X					140	8000	265	10		Clear
1945				X	X					X	X	X		135	8000	260	11		Clear

Figure C-3. Data Collection Form.

APPENDIX D. SCHEME OF ACHIEVING OMNIDIRECTIVITY FOR LORAN-C WITH LOOP ANTENNAS

The bi-directional property of a simple loop antenna is well known. In order for a wideband loop system to be omnidirectional for pulse signals, it should have the same response to signals from all directions. In the case of Loran-C the phase reversal of a magnetic H-field loop antenna produces a figure-8 pattern in space with opposite phase signals on either side of the two figure-8 lobes. Thus the direction of arrival of the pulse groups from different stations in the chain would be required to insure that the same relative phase difference is measured between stations. i.e., A compass or direction indicator needs to sense roughly where the aircraft is oriented with respect to the stations used so as to apply the proper phase reversal to the pulse subtraction in the Loran-C processor. If two or more loops are used it is not possible to combine their outputs to give a single phase sense in a simple summing circuit.

A squaring circuit has been suggested to solve the directional problem [26]. A squaring circuit is a multiplier which multiplies the signal by itself, sometimes also called a frequency doubler. Thus a signal $e(t)$ at some orientation θ with respect to the loop antennas oriented 90° to each other will provide $e(t)\cos\theta$ and $e(t)\sin\theta$ at two loops. Two separate and independent low level squaring circuits produce $e^2(t)\cos^2\theta$ and $e^2(t)\sin^2\theta$ as in Figure D-1. When these two products are summed in a summing amplifier, then the output is now $e^2(t)$ and the phase sense has been eliminated with the output now at twice the original input frequency. Thus in the case of Loran-C at 100 KHz, the output of this low-level squaring and summing circuit would now be a 200 KHz carrier signal where the 5 micro-second phase coding is eliminated and the direction of arrival of the signal is cancelled or also disappears. No compass input to the receiver is needed with this squaring and summing technique.

The Loran-C processor downstream from this input manipulation then has to process 200 KHz pulse signals. A frequency doubler or squarer circuit inherently removes phase reversal information from the original signal.

To our present knowledge this technique has not been used in present Loran-C receiver systems possibly for the reason of added complexity with loop antennas and possibly due to the fact that multiplication is a somewhat noisy process which may reduce the effective risetime of the pulse groups. However, further study of this technique with modern IC low-level multipliers or squarer circuits might uncover some alternate methods for designing Loran-C receivers either with loop antennas requiring no directional sensing, or to eliminate the phase code for a simpler processor, but now working at 200 KHz instead of the usual 100 KHz.

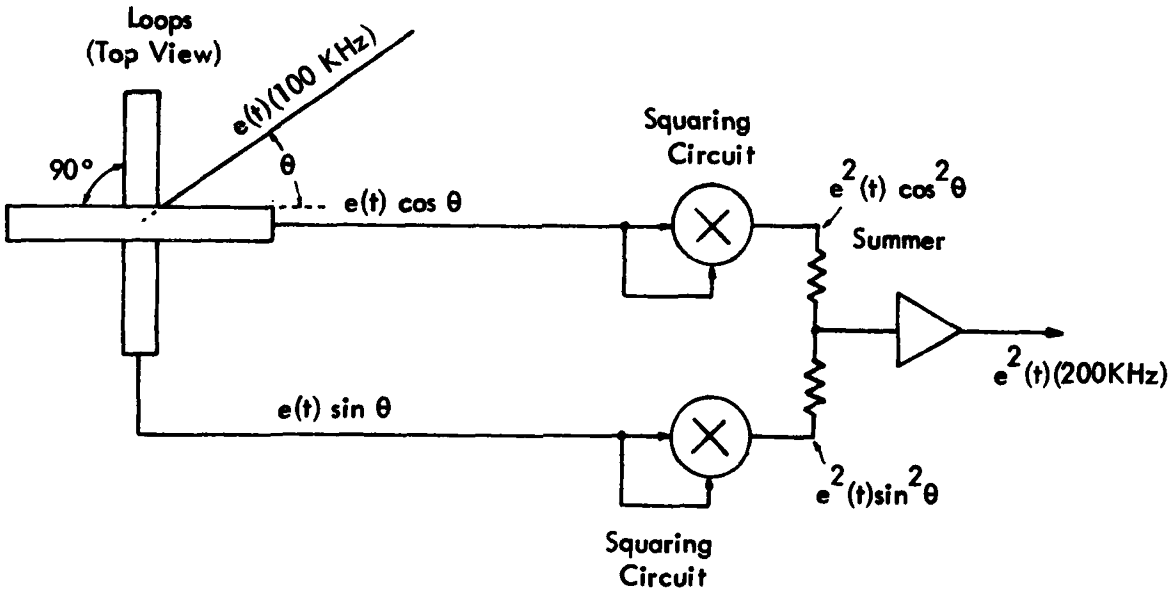


Figure D-1. Loop Antennas and Squaring Circuitry.

VII. ACKNOWLEDGEMENTS

The authors acknowledge project assistance given by the late Professor G.E. Smith and student interns James Irvine and David Bernard, and technician Richard Zaulek in the accomplishment of this literature search and aircraft instrumentation program.

The support given by Dr. R.H. McFarland, Director, Avionics Engineering Center, and the report and administrative sections is appreciated.

Photographs are by Kris Tondra, graduate intern, Avionics Engineering Center.

Personnel at the FAA Technical Center, the Truax Company and Dayton Aircraft Products, Inc., were especially helpful.

DA

FIL